MAKING IN THE MIDST OF PANDEMIC:

THE IMPACT OF THE COVID-19 PANDEMIC ON TWO PUBLIC LIBRARY MAKERSPACES

by

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A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in Educational Technology

Boise State University

August 2022

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the dissertation submitted by

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Dissertation Title: Making in the Midst of Pandemic: The Impact of the COVID-19 Pandemic on Two Public Library Makerspaces

Date of Final Oral Examination: 25 April 2022

The following individuals read and discussed the dissertation submitted by Stacey Woods, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

This dissertation is dedicated to my children—Kaitlyn, Brandon, and Julia—who encouraged and supported me throughout the twists and turns of this journey.

ACKNOWLEDGMENTS

I would like to express my gratitude to my advisor, Dr. Yu-Chang Hsu, whose positive attitude, encouragement, and guidance carried me through each step of this project. Dr. Hsu's pep talks rejuvenated me at just the right moments. I am thankful to Dr. Ching for her specific and constructive feedback which nudged my thinking and helped to shape my research. I am grateful for Dr. Perkins's feedback as well, but even more so for the reminders early on about endurance which propelled me forward when I was not sure I would succeed. To my colleague, Dr. Robert Dalton, I thank you for setting the example for me to follow and reminding me that learning is for a lifetime.

ABSTRACT

This qualitative research explored the impact of the COVID-19 pandemic on makerspaces in the United States which were subject to public health guidelines and challenged with limited/no access to facilities. This multi-case study examined two public library makerspaces, and addressed these research questions: (1) How did the pandemic affect makerspace operations and access, and the teaching and learning that occurs there? (2) How did makerspace leaders respond to the challenges of the pandemic? (3) How did makerspaces evolve during the COVID-19 pandemic? I developed the *Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* which informed the research questions and functioned as template for the research. I collected data digitally and used qualitative coding for within- and cross-case analysis. Findings indicated that the makerspaces shifted from a physical to a virtual setting using community of practice elements. Makerspace staff responded to challenges by reallocating or seeking alternate funding, embracing virtual opportunities to engage patrons in events and instruction, implementing online scheduling calendars, and restructuring services to offer maximum events/access. The makerspaces evolved in terms of staffing, funding, operations, equipment, and offerings. Findings support makerspaces as communities of practice. The study informs makerspace professionals who are adapting to change.

Keywords: makerspace, public libraries, COVID-19, pandemic

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LIST OF ABBREVIATIONS

3D	Three Dimensional
BSU IRB	Boise State University Institutional Review Board
CDC	Center for Disease Control
CoP	Community of Practice
COVID-19	Coronavirus Disease
LSTA	Library Services and Technology Act
MIG	Metal Inert Gas
NGA	National Governors Association
ODH	Ohio Department of Health
PPE	Personal Protective Equipment
QDAS	Qualitative Data Analysis Software
WHO	Word Health Organization

CHAPTER ONE: INTRODUCTION

Makerspaces are exactly what the term implies--spaces where people make things. With such a broad definition, these spaces have existed as long as humans have been making things in places such as workshops, art studios, and even homes. Halverson and Sheridan (2014) noted that scholars have referred to cave paintings as evidence of ancient making.

The maker concept involves three key elements: makers, making, and makerspaces (Halverson & Sheridan, 2014; Hsu et al., 2017). It has its modern roots in Papert and Solomon's (1971) “Twenty Things to Do with a Computer.” Dougherty’s more recent efforts with the launch of *Make: Magazine* in 2005, the introduction of Maker Faires in 2006, and an all-things-maker Internet home at *Make* (makezine.com) were foundational in the recent rise of makerspaces. During the past decade, makerspaces emerged in public places, providing people access to otherwise inaccessible technology. Globally, makerspaces experienced 14 times growth from 1997 to 2017 (Freeman et al., 2017). Maker Media (2013) calls this renaissance of do-it-yourself (DIY) culture the “maker movement” (p. 2). Other maker-oriented websites such as thingiverse.com and instructables.com provide not only do-it-yourself instructions, but they also maintain online communities for makers to post their projects and collaborate with one another. Makerspaces are places where makers interact with materials, equipment, and each other. Freeman et al. (2017) argued that making encompasses all hands-on learning which equates learners with creators.

Makerspaces emerged in a variety of educational environments. People of all ages engaged in tinkering, creative play, and collaboration in the spaces. Makerspaces have a variety of names--hackerspaces, fab(rication) labs, idea labs, digital commons, or studios to list a few (Davee et al., 2015; Halverson & Sheridan, 2014; Koh & Abbas, 2015; Moorefield-Lang, 2015). They are located in many different types of places: museums, homes, community organizations, businesses, public libraries, university/college libraries and K-12 schools (Brady et al., 2014; Dougherty, 2012b; Moorefield-Lang, 2015; Peppler & Bender, 2013; Resnick, 2014; Woods & Hsu, 2019).

Makers--people who do the making--are passionate and enthusiastic in their efforts to create projects, to experiment with equipment, and/or to learn new skills (Dougherty, 2012a). The activities in the spaces are spearheaded and guided by the interests and creativity of the makers themselves. Makers may have participated in the first makerspace activities in a public library circa 1800, although the first 21st century makerspace in a public library is credited to be the Fayetteville (NY) Free Library's FFL Fab Lab (Good, 2013).

Dougherty (2012a) suggested that schools consider integrating making as a way to fuel innovation. Freeman et al. (2017) reported that makerspaces are associated with activities that require higher-order thinking skills, problem-solving, creativity, and self-directed tinkering. They also noted that the makerspace culture embraces failure and iterations which are not often associated with formal schooling. Computational thinking is associated with problem-solving, an activity that is also associated with makerspaces. Ching et al. (2018) analyzed educational technology tools that involved programming

skills and computational thinking. Such tools could be used in a makerspace setting to encourage computational thinking.

Since 2015, the New Media Consortium (NMC) and the Consortium for School Networking (CoSN) has recognized makerspaces as an emerging digital technology with potential for influencing teaching and learning in K-12 schools and more recently has named makerspaces a global movement (Freeman et al., 2017). Dougherty referred to psychologist Jean Piaget as he explained this transformation in terms of creating an internal change in the mindset of students who move from being directed learners to self-directed learners (Whittaker, 2013).

Hatch's (2014) manifesto identifies and expands upon nine principles of makerspaces: make, share, give, learn, tool up, play, participate, support, change. These principles reflect a place where sharing, collaborating, and community-building occur. The activities in a makerspace require the sharing of materials and/or equipment, ideas, techniques, expertise, and mindset (Burke, 2015; Freeman et al., 2017; Hatch, 2014). Makers, both experts and novices, collaborate to solve problems, learn, and create innovative products (Burke, 2015; Hatch, 2014; Kurti et al., 2014; Peppler et al., 2015). Communities form among makers, but beyond that, they expand into other established communities to form partnerships and extend innovation (Burke, 2015). Peppler et al. (2015) emphasized the "close" collaboration that is found in makerspaces. In Hatch's principles, this closeness is represented in physical, emotional, and cognitive ways. Recently, makerspaces and the institutions that contain them have been met with an unprecedented challenge--the COVID-19 pandemic.

According to the World Health Organization (WHO) (2020), the first report of "viral pneumonia" from an unknown origin surfaced in December 2019. Ten days later, the WHO determined the cause of the outbreak to be a novel coronavirus (COVID-19) with the first death reported on January 11, 2020. Cases surfaced in the United States on January 20, 2020. Beginning in February with Washington state, governors began to declare states of emergency. WHO officials declared the rapidly spreading coronavirus outbreak a pandemic on March 11, 2020. The next day, 34 United States governors issued a state of emergency and/or a public health emergency (Hodge, 2020; National Governors Association [NGA], 2020). President Trump (2020) issued a proclamation declaring a national emergency in response to the COVID-19 pandemic on March 13, 2020. The remaining state governors then followed suit releasing similar declarations (Hodge, 2020; NGA, 2020). Governors' orders continued in various frequencies and degrees restricting and/or closing non-essential/non-critical public spaces including schools, stores, restaurants/bars, events, and other public spaces (NGA, 2020). These orders affected libraries where makerspaces were established and thriving: public libraries, universities, and K-12 schools. Orders ranged from stay-at-home mandates to curfews to limiting interaction to small groups. They included recommendations from the Centers for Disease Control and Preventions (CDC) to maintain a distance of six feet from others, referred to as physical or social distancing, and to wear a mask to prevent the spread of the virus. Gradually, governors and state agencies developed reopening plans and released guidelines/restrictions that allowed many of these places to reopen in phases under new protocols which included elements such as social distancing, masking, sanitization, and capacity limitations (NGA, 2020). Reopening timelines varied state-to-

state and even county-by-county within states as government leaders tracked data regarding virus spread across regions. Business and education leaders of these non-essential/non-critical institutions worked to develop reopening plans that reflect various models and often phases of openings. By the end of 2021, vaccines and boosters were widely available in the United States. Masking requirements varied widely, and there was no indication of the pandemic's end.

Statement of the Problem

In March 2020, as a result of the President's proclamation and governors' orders, schools, universities, and public libraries were closed as were the makerspaces contained within them. After several months, these spaces began reopening with various access and capacities nationwide. Guidelines came with reopening. These guidelines favored distance, not closeness; individual equipment, not sharing; limited capacity, not community. While the guidelines were perhaps useful in limiting the spread of a virus, they presented challenges to makerspace leaders and participants who are focused on making, sharing, collaborating, and building community.

As a school library media specialist, I began creating a makerspace in my high school/middle school library five years ago by encouraging a maker mindset, and purchasing materials and equipment for students to use collaboratively. Prior to the pandemic, students in my makerspace shared materials and equipment, worked closely together often in hand-over-hand activities, and collaborated in small groups. The operations in this hands-on, space of close collaboration were challenged in a hands-off, physically distanced world reacting to pandemic. I was curious as to how other

makerspace leaders were responding to these issues and how makerspaces would change as a result, which was the impetus for designing and conducting this research.

Purpose of Study

The purpose of this descriptive case study was to describe how makerspace leaders have adapted and continue to adapt their environments in the context of the COVID-19 pandemic. K-12 school, academic (university) library, and public library makerspaces were subject to guidelines that had the potential to change pre-COVID protocol and daily use of the space. Because the leaders and makers had not experienced a pandemic of this magnitude in their lifetime and continued to be faced with uncertainty indefinitely, they were tasked with an uncharted endeavor: developing and implementing reopening plans. I examined makerspace reopenings at two established public libraries which differed in access, programming, and leadership to identify common and unique responses, and provide some insight into how makerspaces might evolve as a result of the leaders' responses and actions.

The COVID-19 pandemic presented a unique emergency situation which affected these learning spaces nationwide. Other emergency situations (e.g., hurricanes, wild fires, flooding) have affected other towns/cities in the past. An unforeseeable emergency may affect a makerspace in a specific or widespread area in the future. Makerspace leaders who face such an emergency can use the findings of this study to respond to the challenges they are facing. Possible specific contributions include examples of how to provide instruction virtually, how to connect with makers/users/patrons virtually, and how to prepare instruction for reopening. Thus, the study provides empirical evidence to support leaders who may still be in the reopening phase or facing a similar challenge.

Context of the Study

Around the world, makers gather in makerspaces--public or private places where they can use materials or equipment, or connect with other makers to engage in activities that typically include technology and result in a tangible product. K-12 school, academic, and public libraries house makerspaces that serve student and community populations. The COVID-19 pandemic is a unique, widespread, and unprecedented worldwide event that has affected people and institutions at every level from international organizations and governments to the individual person. As a result, these institutions and people reacted and behaved in ways quite differently than they did before. Makerspaces were not spared.

In this study, I examined two public library makerspaces in two cities, one in the western United States and one in the mid-Atlantic region. Both makerspaces were established prior to pandemic, received primarily municipal funding, and offered in-person access to their equipment and events. At the onset of the pandemic, both spaces were abruptly closed to staff and patrons. While staff members were granted access to the spaces after approximately three months, patrons were not permitted inside for months. A detailed description of each site is discussed in the Sample of the Study in Chapter Three.

Conceptual Framework

For this study, I developed the *Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* in Figure 1.1. The study is focused on the access and operations of public library makerspaces as well as the teaching and learning that occurs there. The context, the COVID-19 pandemic, is represented in the upper left corner of the framework. The two large circles represent the two sites in the study and the

focus on the access and operations on each in terms of teaching and learning. I included several elements which are based on the literature review and my own experience. These elements—*makerspace staff, physical setting, user interactions, communication, activities*, and *makers*--are located in small, overlapping circles. I also included two elements, *government mandates* and *health recommendation*s, which have influenced communities and fluctuated since the beginning of the pandemic. I posited that these elements would lead to a description of the access and operations in terms of teaching and learning. I placed the element *government mandates* in the center because these mandates influenced the other elements in the makerspace within the context of the pandemic. The boxes below the large circles represent common responses of the sites to the pandemic situation and the evolution of the makerspaces from before the pandemic to the time of reopening.

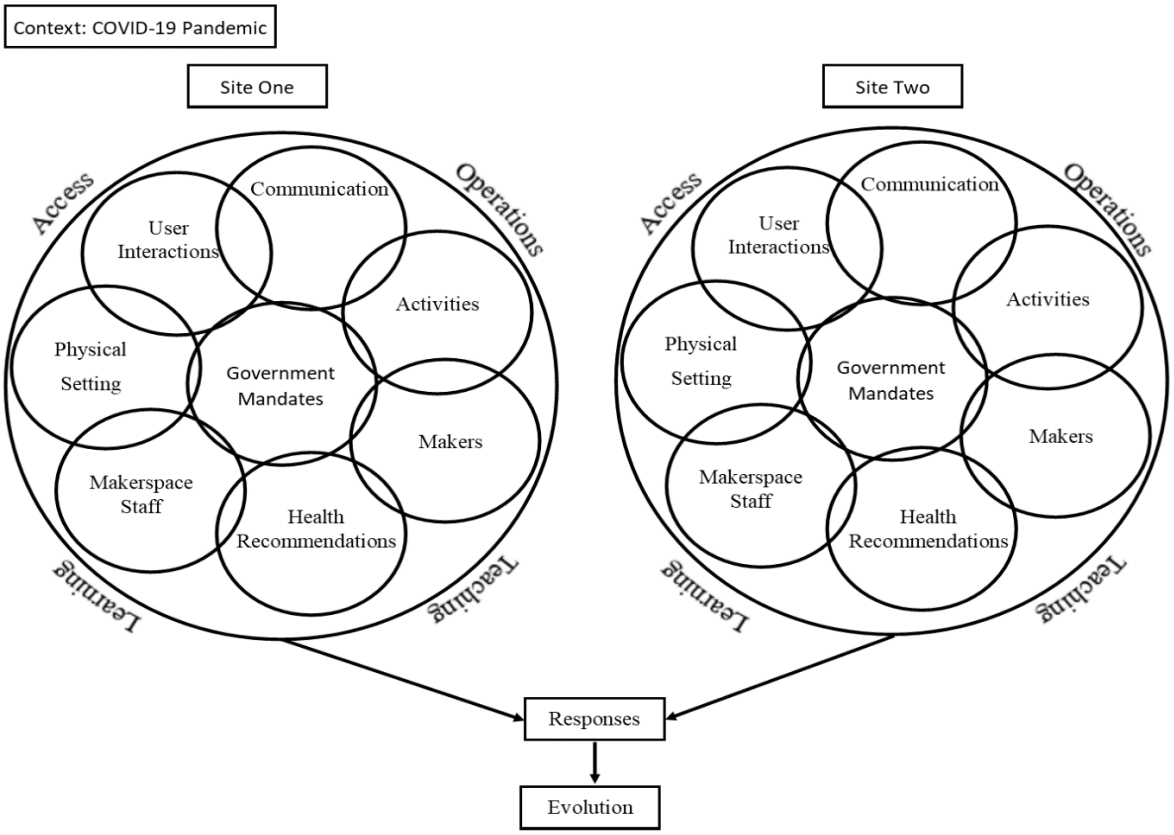

Figure 1.1. Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces

This framework is a graphical representation of the concepts to aid me in data collection as directed by Miles et al. (2020, p. 15). I used the elements included on this conceptual framework when I crafted my interview questions and considered codes for analysis. More details are included in Methods.

Overview of Research Methods

This study follows a descriptive, multiple case-study research design. Qualitative research and, more specifically, case-study research focuses on the pursuit of deep understanding of an issue, a problem, or a case itself within a particular, bounded case in

a specific context or setting (Creswell, 2013; Flyvbjerg, 2007; Miles et al., 2020; Mills et al., 2010; Simons, 2009; Yin, 2013, 2014).

Research Questions

Research questions serve various roles in a study including providing a "framework," illustrating boundaries, reflecting the problem, serving as an organizational tool, and foreshadowing (Onwuegbuzie & Leech, 2006, p. 477). The following research questions guided this study:

RQ1: How has the pandemic affected makerspace access and operations, and the teaching and the learning that occurs there?

RQ2: How have makerspace leaders responded to the challenges of the pandemic?

RQ3: How have makerspaces evolved during the COVID-19 pandemic?

Sample

Yin (2014) warned against the inclusion of only one case and emphasized that the inclusion of just one additional case would produce stronger results. To establish a rationale for multiple cases, he suggested researchers search for a second case which could supplement or fill in any gaps left by the first case. Thus, findings would likely be strengthened. Therefore, this descriptive case study includes two cases of public libraries makerspaces chosen through purposeful, convenience sampling (Miles et al., 2020). Criteria for case consideration included (a) a public library makerspace setting that was established and active prior to March 2020, and (b) makerspace leaders who were willing to share their experiences concerning the effects of COVID-19 on their makerspaces.

Preference was given to accessible cases that exhibited the most potential for learning due to their depth and breadth of response, and/or their unique response to the situation.

Data Collection and Analysis

Data sources in this study included the following: interview data with participants, virtual field observation data, public recordings, website postings, and documents (policies, articles, procedures, etc.). Data collection took place virtually through video-conferencing and through examination of case websites and electronic documents. Semi-structured interviews followed an interview protocol based on researchers' recommendations, and included in-the-moment questions in conjunction with emergent topics (Creswell, 2013; Merriam, 2009; Miles et al., 2020; Stake, 1995).

I used comparative analysis to analyze the data. Data were uploaded into NVivo QDAS for within case analysis to identify themes as I began describing each case in its own context (Miles et al., 2020). I focused on assigning process codes as I examined the data in multiple cycles. Once I analyzed each case individually, I performed cross-case analysis. Table 1.1 aligns the research questions to the data analysis.

Table 1.1. Alignment of Research Questions to Data Analysis

Research Questions	Data	Data Analysis
RQ1: How has the pandemic affected makerspace access and operations? RQ2: How have makerspace leaders responded to the challenges of the pandemic? RQ3: How have makerspaces evolved during the COVID-19 pandemic?	Virtual interviews Virtual field observations (tours) Website pages Social media postings Policy documents Programming brochures or postings Public videos	Within-case ongoing, cyclical comparative analysis: Reflective journaling Data uploads into NVivo QDAS Transcription Process coding (Saldaña, 2021) Visualization of emerging codes/codebook Descriptive and pattern coding (Elliott, 2018; Miles et al., 2020) Code reduction (Fram, 2013) Cross-case analysis: Matrix display NVivo exploration and comparison toolstools Reflective journaling Data uploads into NVivoQDAS Transcription Process coding (Saldaña, 2021) Visualization of emerging codes/codebook Descriptive and pattern coding (Elliott, 2018; Miles et al., 2020) Code reduction (Fram, 2013) Cross-case analysis: Matrix display NVivo exploration and comparison tools

To triangulate the data, I included multiple data sources and types, and revisited data to double-check impressions and findings. In regard to these methods, Miles et al. (2020) referred to triangulation as a process that should occur throughout the research process. As I examined the data, I weighed the data, being mindful of not only frequency but also of the richness of the data to determine significance.

Scholarly Significance

I conducted this unique research as the world experienced the COVID-19 pandemic. Because makerspaces had not been challenged by such a situation before, the research informs makerspace leaders who are still in planning phases of reopening or who would like to learn about how other leaders responded to the COVID-19 pandemic. In the future when other challenges arise, makerspace leaders have this empirical study to guide them in response strategies. Current research about makerspaces during the pandemic is limited. Therefore, this study filled a gap in the research surrounding makerspaces. This study serves as a starting point for other researchers or studies, which can help serve the maker education and research community.

Chapter Summary

Makerspaces are emerging in library settings. In this case-study research, I examined two established public library makerspaces in order to provide empirical data for other library makerspace leaders to use when considering their reactions to challenges similar to the COVID-19 pandemic. Restrictions and guidelines from federal, state, and local governments as well as from the CDC challenged the typically hands-on community-oriented environment of public library makerspaces. Makerspace leaders have responded in a variety of ways. Using data drawn from virtual interviews and tours,

documents, public videos, and website postings, I used NVivo QDAS to explore, analyze, describe, and draw conclusions about (a) how the pandemic has affected these makerspaces, (b) how the makerspace leaders have responded to the challenges of the pandemic, and (c) how the makerspaces have evolved during that time.

CHAPTER TWO: LITERATURE REVIEW

Makerspaces are places where people make projects and tinker. There, makers engage in hands-on activities often using technology and sharing ideas among themselves. Since the onset of the COVID-19 pandemic, leaders in library makerspaces faced the challenge of providing services even as government orders have limited access to or closed facilities. This chapter contains a review of information found in the literature concerning library makerspaces and the COVID-19 pandemic.

Makerspaces are a growing national and global phenomenon (Burke, 2015; Freeman et al., 2017; Maker Media, 2013; Moorefield-Lang, 2015; Peppler & Bender, 2013). Makerspaces are spaces where people often known as makers create products. Defining makerspaces is less about the physical characteristics of the setting and more about the activities--called making--that occur there. Some researchers refer to this idea as a community of practice (Halverson & Sheridan, 2014; Hsu et al., 2017). Making can be described as "experimental play" (Maker Media, 2013, p. 3). Martin (2015) presented a more-expanded "working" definition: "…a class of activities focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a 'product' of some sort that can be used, interacted with, or demonstrated" (p. 31). Makerspaces are known by a variety of other labels such as hackerspaces, fab labs, idea labs, digital commons, or studios depending on their specific focuses such as fabrication or digitization (Halverson & Sheridan, 2014; Koh & Abbas, 2015; Moorefield-Lang, 2015).

Nearly any place where people are making things can be deemed a makerspace. Makerspaces are found in museums, homes, community organizations, and businesses (Peppler & Bender, 2013) as well as public libraries, university/college libraries, K-12 school classrooms, and K-12 school libraries (Brady et al., 2014; Dougherty, 2012b; Moorefield-Lang, 2015; Peppler & Bender, 2013; Resnick, 2014). They stem from the Maker Movement, a large-scale effort to encourage making (Maker Media, 2013). The activities that occur in makerspaces typically involve some type of technology (Hsu et al., 2017).

Makerspaces in Public Library Settings

Technology is no stranger in the library. Public libraries have long been known for making expensive equipment such as copy machines and computers accessible to library patrons. Resnick (2014) observed that public libraries are transforming from information warehouses into technological community hubs featuring 21st century equipment and ideologies. These hubs are makerspaces. Resnick described one library's collaborative space as "part workshop, part technology petting zoo."

Meg Backus of the Chattanooga Public Library advocated for libraries to adapt from a static environment to a collaborative one, similar to the transformation that occurred surrounding the evolution of the Internet (Resnick, 2014). The maker movement is a part of that change. The concept of democratization--to provide free and equal access to all--is common to libraries and making (American Library Association, 2015; Freeman et al., 2017; Halverson & Sheridan, 2014; Hsu et al., 2017). Libraries are dedicated to the idea of providing free access to technologies that individuals may not be able to afford or want to purchase, but would like to utilize (Burke, 2015; Resnick, 2014).

Library makerspaces attract a variety of people. Dougherty (2012a) claimed that making is an innate human activity; therefore, everyone is a maker. All types of people--children, teens/youth, adults, males, and females--can be makers (Hsu et al., 2017; Peppler & Bender, 2013; Resnick, 2014), although they may use these innovative library spaces for different reasons. Often, some are inexperienced (Moorefield-Lang, 2015). Others are experts in one craft, technology, or activity, and share their knowledge with others (Koh & Abbas, 2015). The literature reflects the varying levels of expertise that makers have (Hsu et al., 2017). The characteristics of makers are diverse (Hsu et al., 2017), and the spaces themselves tend to be welcoming and inclusive (Peppler & Bender, 2013). The American Library Association (2015) is adamant that library materials and services be available and accessible to all people. This accessibility extends to the library makerspace (Brady et al., 2014; Halverson & Sheridan, 2014).

Loertscher et al. (2013) developed the uTEC Maker Model framework to illustrate the progression of activities that novice makers may experience as they move from creating guided projects to proposing and designing their own projects. The researchers designed the framework with four levels: using (following instructions or using equipment in the way it was intended to be used), tinkering (altering the instructions or using equipment for a slightly different purpose), experimenting (working to design something new and learning from failures), and creating (designing a unique, creative product). They posit that the model will help librarians to facilitate learning with makers in makerspaces.

Libraries host events called Mini Maker Faires (Britton, 2012) to encourage makers and to give experienced makers an outlet for sharing, or library makers can

participate in and/or attend larger Maker Faires (Halverson & Sheridan, 2014; Moorefield-Lang, 2015). These faires are gatherings where makers of all levels of expertise can gather to make, share ideas, and display their projects, and they may also be used as sources for activities (Maker Media, 2013; Peppler & Bender, 2013).

Loertscher et al. (2013) claimed that making has always been part of library culture in the form of models, posters, video presentations, and crafts created by patrons. The range of activities are vast and involve interaction with technology, either traditional or digital (Hsu et al., 2017). These activities constitute informal learning opportunities that may boost K-12 formal learning (Halverson & Sheridan, 2014) and empower students to pursue STEM careers and invent new ones (Kalil, 2010).

Profiles of Library Makerspaces

The literature includes profiles of library makerspaces around the United States. These provide a glance inside existing spaces that reveals activities, users, leaders, and equipment.

Britton (2012) described the Westport Public Library's (Connecticut) focus on encouraging entrepreneurship. Innovative activities included hosting a Mini Maker Faire (Britton, 2012) and adopting a maker-in-residence program featuring expert makers (Britton, 2012; Peppler & Bender, 2013). Makers-in-residence workshops have involved building wooden airplanes, constructing musical instruments with Makey Makey kits, and sewing digital quilts (Peppler & Bender, 2013). The library hosted a mini maker faire featuring demonstrations and do-it-yourself instructional presentations (Britton, 2012).

In an effort to examine the use of 3D printers and makerspaces in libraries, Moorefield-Lang (2014) studied six libraries in various settings. The convenience sample

included two K-12 school libraries, two public libraries, and two university libraries. K-12 school librarians reported that each library had a staff of one librarian. In each school, the librarian experienced challenges with 3D printing including print time, frequency of failed products due to machine and/or design error, and maintenance. The librarians worked to connect 3D projects with curriculum. Such projects included making gems in conjunction with a science unit on rocks and minerals, and charms to make bracelets as a service project. Both librarians described the excitement associated with their respective makerspaces.

In Moorefield-Lang's (2014) study, the public libraries reported an increase in makerspace equipment. In addition to a 3D printer, materials such as art supplies, audio and video creation technologies and software, supplies for sewing and silk-screening textiles, and Arduino circuitry and robotics were available. One 3D printer was reportedly acquired using crowdfunding (Donors Choose). Projects/activities included creating robotic animals for a petting zoo display, 3D-printing fairy tale characters and Olympic symbols, and partnering with one of the K-12 libraries on the charm service project. Librarians reported that the popularity of the 3D printer and its maintenance were challenging, but they focused on the positive aspects of 3D printing.

Each of the university libraries that Moorefield-Lang (2014) studied reported owning three 3D printers. The spaces each had one dedicated manager, and offered classes, workshops, and projects mainly geared toward curriculum (chemistry, art, medical science, engineering). Projects included printing tools for chemical experiments, and rendering a computer design of children's noses from an MRI scan to create 3D models for practicing extraction of foreign bodies from small nasal cavities. Librarians

identified several challenges: (a) creating policies for space use, (b) training users, and (c) meeting the demand for services.

Moorefield-Lang (2014) found that personal learning networks may be helpful for librarians to get information about equipment and other makerspaces. Other findings indicated that face-to-face and online trainings are options for educating patrons about equipment usage. However, Moorefield-Lang noted that the primary concern should be how to best meet patron needs. The research indicated both grants and existing budgets to be potential sources for funding. Overall, Moorefield-Lang recommended that librarians draft and implement guidelines, protocols, and training for makerspace users.

In another study, Moorefield-Lang (2015) interviewed twelve K-12, university/academic, and public librarians. Moorefield-Lang identified training for librarians, training for patrons, makerspace implementation, staffing, and reactions as themes. She found that librarians deployed makerspaces to increase library usage, sought training through peers and online sources, and were employed as the only librarian at the K-12 and university levels. These librarians trained patrons in face-to-face and online environments, utilizing community experts. Moorefield-Lang described a wide variety of activities offered by the Detroit Public Library Teen Hype Center, a makerspace exclusively for teenagers. The activities included 3D printing, bike repair, motion-controlled video gaming, soldering robotics, sewing, silk screening, poster-making, knitting, cross stitching, and paper crafting. All of the libraries reported 3D printing as a common activity.

Common Elements of Makerspaces

More broadly, an examination of the literature reveals common elements--physical settings, technologies, activities, collaboration, and leaders--associated with makerspaces.

Physical Settings

A library makerspace is any space within a library where makers make things (Britton, 2012). Others define makerspaces as communities of practice (Halverson & Sheridan, 2014; Hsu et al., 2017). Maker Media (2013) defines makerspaces as "physical spaces" for making and identifies libraries as potential settings for makerspaces because of their reputation for sharing resources. Literature is sparse in elaborating on the physical locations, dimensions, and arrangements of makerspaces in libraries. Where details about designated areas are cited, descriptions vary. The makerspace at the Chattanooga Public Library (Tennessee) takes up an entire floor (Resnick, 2014). Other makerspaces are housed in repurposed rooms (Odom Library at Valdosta State University) or areas referred to as designated spaces or centers (Burke, 2015).

Good (2013) described three library makerspaces. At the Allen County Public Library (Indiana), a 50-foot by 10-foot trailer in a lot across the street from the library served as the library's makerspace. Cleveland Public Library (Ohio) built a 7,000 square-feet addition to house its makerspace. The space included a computer lab with 90 workstations and round tables for encouraging collaboration. A library at the University of Nevada in Reno moved print items that experienced low usage into storage to free up 18,000 square feet of space. Furnishings included repurposed furniture from the

university, a closed library nearby, and a school district. Instead of expensive white boards, the director opted for covering the walls with whiteboard paint.

Technologies

Technologies in library makerspaces range from low- to high-tech with the spaces themselves often focusing on either arts or technology, or a combination of both (Burke, 2015; Moorefield-Lang, 2015) based on user interest and resources (Brady et al., 2014).

For years, many libraries have offered computers for patron use and will continue to do so. Some have expanded to include software for video and audio production, coding, and gaming (Burke, 2015; Moorefield-Lang, 2015; Resnick, 2014). A wide variety of materials and technologies are identified in the literature. Examples of high-tech equipment in library makerspaces include 3D printers and 3D modeling software, laser and vinyl cutters, computer numerical control (CNC) routers, and robotics (Brady et al., 2014; Burke, 2015; Koh & Abbas, 2015; Moorefield-Lang, 2015; Range & Schmidt, 2014; Resnick, 2014). Electronics such as Arduino and circuit building kits, Raspberry Pi, and e-textiles (Burke, 2015; Koh & Abbas, 2015; Moorefield-Lang, 2015) appeal to children and teens. Less expensive items include craft supplies and button makers (Burke, 2015; Resnick, 2014). Traditional tools including sewing machines, hand tools, power tools and soldering irons are also listed in the literature (Koh & Abbas, 2015; Maker Media, 2013; Resnick, 2014).

A makerspace can be started with any number or combination of technologies. Participants in Burke's (2015) survey of academic, public, and K-12 makerspaces reported offering an average of nine different technology/activity options. The Detroit Public Library Technologies' teen makerspace opened with six soldering irons, a vinyl

cutter, bike repair toolkits, a wireless color printer, and eight Arduino kits (Britton, 2012). Perhaps the most common technology associated with makerspaces is a 3D printer (Britton, 2012; Moorefield-Lang, 2014, 2015). Burke (2014) found that makerspace leaders choose equipment based on the technologies found in other makerspaces and recommendations from educators and patrons. *The Makerspace Playbook School Edition* which contains lists of reusable tools and consumable materials commonly found in makerspaces can be used for reference (Maker Media, 2013). A 3D printer is not required, and while lists of suggested materials can be found online, there is no specific list of required technologies or equipment in a makerspace (Britton, 2012; Maker Media, 2013).

West Port Public Library (Connecticut) Director Maxine Bleiweis emphasized that by providing equipment and access to resources, libraries create a framework for making (Britton, 2012). In addition, Peppler and Bender (2013) asserted that people who may not otherwise have identified as makers will have opportunities to participate when they are exposed to making at a library. Such participation may increase diversity in the maker population which has been criticized for focusing on white males (Halverson & Sheridan, 2014).

Activities

Making is informal and intrinsic with a focus on maker engagement and process (Halverson & Sheridan, 2014; Maker Media, 2013). As such, maker activities and technologies should be chosen so that they invite open inquiry which may lead to deep understandings (Maker Media, 2013). Burke (2015) categorized the several types of activities occurring in library makerspaces as hands-on learning, collaborative projects,

self-directed inquiry, STEM projects, prototyping, tinkering, and idea sharing. He deemed the library to be the "best place for a makerspace" on campus because of its interdisciplinary, open culture (p.503).

Activities in a makerspace should be maker-driven, not standards-driven (Peppler & Bender, 2013). Yet makerspaces in academic and K-12 libraries may reflect the standards-based educational environments. Burke (2015) suggested that technologies and activities in library makerspaces may depend on the type of library (public, academic, or K-12). He found that creative, digital products are more common in academic libraries which may be linked to formal learning. He posited that the activities in academic libraries may be tied to curriculum standards or requirements instead of being user-driven.

Resources for activities are available online at The Maker Ed Initiative's (Maker Ed) website which supports making in education through its vast library of maker activities and activity guides for facilitators. Other online activity sources include Thingiverse.com, Instructables.com and DIY.com (Peppler & Bender, 2013).

Loertscher et al. (2013) developed the uTEC Maker Model framework to illustrate the progression of activities that novice makers may experience as they move from creating guided projects to proposing and designing their own projects. They designed the framework with the following four incremented levels: using (following instructions or using equipment in the way it was intended to be used), tinkering (altering the instructions or using equipment for a slightly different purpose), experimenting (working to design something new and learning from failures), and creating (designing a unique,

creative product). Loertscher et al. posited that the model will help librarians to support makers.

Collaboration

Collaboration in makerspaces occurs in two main areas: funding and learning. From the administrative perspective, partnerships can result in funding and materials. Collaborative projects between makerspace professionals and/or among makers themselves can be authentic problem/project-based learning experiences. Koh and Abbas (2015) identified the ability to establish and maintain collaborative partnerships as one of the top competencies for makerspace professionals. This ability includes collaboration with makers, grant-writing and funding partners, and people across disciplines.

Collaborative funding efforts are evident in several ways in the makerspace literature. Procuring space and equipment, and securing sources of funding are a few. Both the University of Nevada and the Allen County (Indiana) makerspace efforts hinged on collaboration (Good, 2013). At the University of Nevada library, the university dean assisted by securing an internal grant, and another campus library donated materials (Good, 2013). The Allen County makerspace was born from a partnership between the library director who needed space for a makerspace and the president of TekVenture who needed a physical presence for his business (Good, 2013).

Hsu et al. (2017) listed several agencies that have partnered with makerspaces to provide funding or other types of support. These agencies include the Department of Education, the Department of Agriculture, the Maker Education Initiative, and the Institute for Museum and Library Services. A Library Services and Technology ACT grant (LSTA) funded through the Institute for Museum and Library Service is one such

grant that is available to librarians. Burke (2015) studied the Kent State University-Tuscarawas (Ohio) regional campus which received funding for its makerspace with an LSTA grant. He noted that the Kent makerspace also partnered with the Ohio Small Business Development Center to provide programming specific to entrepreneurs. Maker Media (2013) referenced 16 grant-funding partners in *The Makerspace Playbook*.

Dougherty (2012b) described the collaboration that stemmed from the Defense Advanced Research Projects Agency (DARPA) grant with a goal to reach underserved populations. The partnership between *Make* magazine and schools took making to high school students by implementing a program for developing curriculum integration, publishing teachers' guides, guiding schools in makerspace design, creating an online platform for project documentation and tracking, establishing a maker network of high schools, and including high school students in maker faires (Dougherty, 2012b). Maker Faires are places for makers to share their products (Peppler & Bender, 2013). Brady et al. (2014) suggested seeking out experienced makers for activity ideas and costs. Maker faires present opportunities for networking and partnerships.

Other partnerships may be established within the librarians' existing network or community. Burke (2015) suggested that academic librarians look to faculty/staff for project expertise or partner with other organizations on campus. Some authors suggested recruiting mentors (Koh & Abbas, 2015; Maker Media, 2013). For example, Koh and Abbas recommended maker-in-residence programs in which expert makers serve as mentors as they use the space and its equipment, hold workshops, and interact with other makers. They also noted that parents, extended family members of teens, and teens themselves can serve as mentors to others. Maker Media (2013) encouraged initiators to

seek collaborative relationships with local foundations and businesses. The authors also recommended seeking support from makers' family members who may be willing to donate tools and materials that they no longer use.

Latham et al. (2016) investigated the perceptions and experiences regarding collaboration among school and public librarians, and science teachers with the intent to provide a foundation for creating a model for collaboration among the groups that would support students' 21st century skills in science. Librarians reported that their collaborative efforts with science teachers included providing information resources and supporting assignments. Science teachers acknowledged that librarians were valuable for providing information resources. The groups identified barriers to collaboration as time and lack of administrative support, while testing, standards-based teaching, and evaluations were given a greater priority than collaboration.

The Buck Institute for Education (2017) developed a framework written from the student perspective for high-quality, project-based learning in schools. The framework is centered on six criteria which must be present in order for the project to be deemed high quality: (a) intellectual challenge and accomplishment, (b) authenticity, (c) public product, (d) collaboration, (e) project management, and (f) reflection. These elements of this framework may correspond with project creation in makerspaces. Problem-based learning is a type of guided inquiry which challenges students to address realistic, open-ended, ill-structured problems and work towards a solution (Friesen & Scott, 2013; Scott et al., 2018). Scott et al. (2018) pointed out that collaboration is a key component of problem-based learning in which students depend on each other for knowledge. In makerspaces, the interaction between makers and staff members illustrates that same type

of collaboration. According to Koh and Abbas, "Building partnerships with other agencies and community members has never been more critical as libraries transform into community learning centers" (p. 18).

Makerspace Leaders

Innovative change in libraries often begins with the library professionals. Corinne Hill, library director in Chattanooga, Tennessee, received *Library Journal's* 2014 Librarian of the Year award for her work in transforming her library with innovative technologies, spaces, and programming (Resnick, 2014). Moorefield-Lang (2015) said that these professionals are typically technology leaders already in their settings and often are lone rangers. She suggested that in order to build successful makerspace programs, librarians should be willing to assume the roles of "innovator, problem solver, and collaborator" (p.108). Maker Media (2013) supports K-12 makerspace initiators with online resources including *The Makerspace Playbook School Edition* which includes detailed information about starting, managing, and maintaining a space. Moorefield-Lang (2015) found that some librarians have taught themselves to use new technologies by studying the documentation, seeking help online, calling tech support, or recruiting passionate student volunteers. She wrote that although pre-service librarians may not have skills to manage makerspaces, they should learn to use technology available at their universities to prepare.

Researchers are beginning to identify new roles and qualifications necessary for librarians, like Hill, who work in or want to create these innovative settings (Brady et al., 2014; Loertscher et al., 2013; Moorefield-Lang, 2015). As leaders in makerspaces, Moorefield-Lang (2015) suggested that librarians must exhibit fearlessness, be

vulnerable, embrace failure, and seek collaboration. As facilitators, they should learn to guide instead of instruct (Brady et al., 2014). Loertscher et al. (2013) asserted that K-12 librarians can be motivators by challenging students with contests, recognizing and exhibiting their projects, and providing time for them to demonstrate what they have created. Burke (2015) found that administrative support is another factor that may determine a makerspace's success.

Koh and Abbas (2015) posited that innovative library initiatives such as makerspaces (hands-on environment) and learning labs (digital environment) must be led by qualified professionals. The researchers interviewed leaders/pioneers in the field to identify competencies required of library professionals who provide library services in these settings. Findings indicated five key competencies: (a) ability to learn, (b) ability to adapt to changing situations, (c) ability to collaborate, (d) ability to advocate for the space; and (e) ability to serve diverse people. Findings also identified key skills: (a) management, (b) program development, (c) grant writing and fundraising, (d) technology literacy, and (e) facilitating learning. Of these competencies and skills, 8 of 10 are addressed in the American Library Association (2009) competences, indicating that trained, educated library professionals meet these recommendations in most areas.

In a second study, Koh and Abbas (2015) surveyed makerspace and learning lab professionals working in the field and found that these professionals must possess the following competencies: (a) technology, (b) teaching/programming, (c) learning, (d) community advocacy and partnerships, (e) flexibility (f) understanding diverse users, (g) management, (h) communication skills, (i) curiosity, (j) creativity, (k) patience, and (l) subject content knowledge and skills. Some competencies in both studies are similar.

Notably, the findings in the leadership/pioneer survey listed technology much lower than those who actually work in the field. Koh and Abbas (2015) asserted that the findings might be used to inform library managers of qualifications needed for makerspace librarians. They may also be used to educate pre-service librarians. Still, Hsu et al. (2017) agreed that education is necessary for the integration of makerspaces into formal environments such as K-12 libraries.

Challenges

Challenges to makerspace implementation arise amid the efforts of even the most qualified personnel. The set of challenges discussed here--emergent nature, training, funding, accessibility, integration with education--represent common concerns referenced in the literature.

Emergent Nature

Although it is difficult to determine when making first appeared in libraries, Good (2013) traced the history back to the late 1800s in Gowanda, New York, where a group of ladies met to engage in needlework and talk about books and formed the Ladies Library Association. The association later received a state charter and became the Gowanda Free Library in 1900. He credited the opening of one of the first 21st-century makerspaces in 2011 to the Fayetteville Free Library (New York). Not only are makerspaces emerging, but new technologies are emerging all the time. Locating resources for start-up, professional development, peer networking, and activities/projects presents one challenge (Moorefield-Lang, 2015).

Training

Professional development is an ongoing challenge because as new technologies are introduced, librarians must be able to use and maintain them. In addition to self-teaching and online tutorials, Moorefield-Lang (2015) suggested librarians establish a professional learning network with other librarians who are implementing makerspaces. In 2014, Carnegie Mellon University (2021) launched a searchable online directory of colleges, universities, and schools which embrace the making culture, including a list of those who have makerspaces. This directory presented an opportunity to connect with other professionals, learn about other makerspaces, or find professional development opportunities. Additional resources are available online (e.g., Instructables.com and DIY.org) and contain projects, instructions, tutorials, and forums to support librarians and educators with developing and maintaining makerspaces (Peppler & Bender, 2013). Maker Ed Initiative works to connect making with education (Peppler & Bender, 2013). The initiative maintains a website that offers online professional development, facilitator guides for implementing activities and projects, links to resources for planning and managing a makerspace.

Research suggests the need for training (Hsu et al., 2017; Moorefield-Lang, 2015). Librarians seeking formal training may choose to access courses that focus on makerspaces and making. These formal courses are offered in both face-to-face and online formats. Hsu et al. (2017) identified institutions that offer face-to-face courses including New York University, Carnegie Mellon University, University of Advancing Technology, Utah State University, and the TechShop. They named the Exploratorium Museum and Stanford University as sources for online courses. They included online

graduate options at Boise State University and the University of Wisconsin-Stout. Loertscher et al. (2013) developed a QuickMOOC (short massive open online course) titled "Makerspaces in Schools and Libraries: An Introduction" to assist librarians with starting makerspace initiatives. Training demands for makerspace librarians are ongoing because training will be necessary as new technology emerges (Moorefield-Lang, 2015).

Funding

Procuring funds to stock and maintain a makerspace is another challenge. While collaborative efforts may help alleviate this issue, librarians may need to examine their library budgets and evaluate current and past spending practices to appropriate monies. This strategy was employed at the successful Chattanooga Public Library (Resnick, 2014). Maker Media (2013) suggested posting requests on online crowdfunding websites (e.g., Kickstarter and Indiegogo). For example, the "THINQubator" Makerspace project listed on Indiegogo raised more than $10,000 for a makerspace for kids. Dozens of makerspace projects are also listed on Kickstarter. Federal, local, and internal grants are also options (Burke, 2015; Dougherty, 2012b).

Accessibility

While makerspace technologies and services are available to all, they may not be completely accessible for all people, including people with disabilities. Brady et al. (2014) studied the accessibility of a public library makerspace event. Participants included people with visual and cognitive disabilities. They identified existing assistive technologies in makerspaces to be limited to individual assistance, large grip tools, and general accessibility to building. In the study, library staff teamed up with FutureMakers to design accessible library makerspace activities. Results showed that offering a variety

of maker stations (i.e., wind tunnel, marble wall, wiggle bots, Makey Makey) to be optimal because while not all of the activities were fully accessible by all participants, a variety of activities ensured that all participants could access ones that focused on their abilities. Brady et al. (2014) suggested that spontaneous adjustments to the makerspace might spark ideas that lead to the design of appropriate assistive technologies for the benefit of the entire user community.

Integration with Formal Education

Halverson and Sheridan (2014) pointed out that the K-12 education with its focus on standards and fixed schedules is inconsistent with the philosophy of the maker movement which advocates hands-on activities and free movement. Halverson and Sheridan stressed that in a makerspace environment, learning can occur, but learning is not guaranteed, measured on state tests, or regulated with standards. Therefore, makerspaces can be at odds with the formal, standards-based model of learning common in schools.

Making in library makerspaces is a variety of project-based and problem-based learning that occurs more formally in schools. Project-based learning revolves around the processes and methods of the creation of a product or a presentation for an audience (Friesen & Scott, 2013). Thomas (2000) determined that in order for an experience to be considered project-based learning, it must have a project that is central, not supplementary, to the curriculum. In makerspaces, product creation is the central goal. Thomas also found that the experience must also contain driving questions or driving problems that are realistic and lead to a constructive, student-driven project. In makerspaces, makers formulate the questions and problems which drive product creation.

Peppler and Bender (2013) stressed that the user-driven nature of making is problematic for teachers and administrators because they are accustomed to top-down education in which the teacher determines the content and activities to meet state or national standards for learning. However, maker-driven inquiry, as it occurs in the makerspace, supports STEM initiatives with hands-on, technology-integrated, interdisciplinary activities (Halverson & Sheridan, 2014; Maker Media, 2013). Because the bottom-up design of making is different from traditional school settings, makerspace projects in these spaces tend to be more guided (Burke, 2015). Halverson and Sheridan (2014) revealed that dedicated members of the maker community fear that educational entities will attempt to standardize makerspaces and making in schools which would destroy the essence of the movement. Halverson and Sheridan asserted that making can provide a way for all students to demonstrate learning, but embracing makerspaces requires a shift in thinking concerning the function of libraries.

Makespace leaders encountered the aforementioned challenges in various degrees as part of the evolution and development of their spaces prior to 2020. While these challenges continue, a unique set of obstacles emanating from the COVID-19 impacted makerspaces in libraries in 2020 and beyond in an unprecedented way.

COVID-19 Pandemic

The COVID-19 virus, a novel coronavirus with pneumonia-like symptoms, first appeared in December 2019. Cases of the virus spread around the world, and the WHO declared a pandemic on March 11, 2020. Two days later, United States government officials began to issue a series of orders which temporarily closed or limited nonessential businesses, limited public gatherings, called for social distancing, and closed

schools. These orders also affected public libraries, including the makerspaces that many housed. As of April 2021, government officials had lifted some restrictions, but many public businesses and areas continue to operate with limited accessibility.

Literature published during the pandemic addressed makerspace functionality during the pandemic. Hepp and Schmitz (2022) examined two case sites in Germany and the United Kingdom and concluded that the makerspace communities at those sites were shocked at the limitations of the makerspaces' practice and ability to mass produce. Carlson et al. (2022) described a university makerspace which had opened just before the pandemic, and offered both virtual and in-person events and activities after in-person access was permitted. Kinnula et al. (2021) outlined several challenges that they faced as educators in a university makerspace serving community children and teachers. These included the shift into online facilitation mode, lack of access to equipment, and the remote support of parents and children.

Public Libraries during Pandemic

From the onset of the government orders, libraries attempted to stay connected with patrons. Alajmi and Albudaiwi (2020) analyzed New York Public Libraries' use of Twitter from the beginning of the pandemic until April 2020. They found that these libraries used the social media outlet to deliver information to patrons in the areas of announcements, recommendations/suggestions, information sharing, and library operations. Alajmi and Albudaiwi suggested that these findings indicated the libraries' commitment to normalcy during the pandemic. As the closures continued, libraries began adapting to the situation. Jones (2020) described several adaptations: (a) expanded wi-fi coverage that included parking lots; (b) implemented curbside services; and (c) increased

online programming such as children's story time or adult presentations/activities. Chisita (2020) argued that librarians played an important role during the COVID-19 pandemic as information literacy professionals with the ability to provide reliable and convenient sources of information in order to overcome the "infodemic of misinformation" (p.12). Wang and Lund (2020) who studied the announcements of 50 libraries over a two-day period at the beginning of the COVID-19 pandemic determined that libraries could indeed play such a role.

Public Library Responses

Breeding (2020) posited that with digital services in place, libraries were in a good position to serve their patrons even while closed. He suggested that the post-pandemic library offerings may reflect the demand for increased digital services brought on by the closures. These services do not necessarily include makerspaces services.

Santos (2020) described a variety of libraries' responses in Texas to the challenges/limitations of the pandemic. Table 2.1 contains a summary of types of services these libraries offered when during closure or with limited accessibility.

Table 2.1. Responses of Libraries in Texas to the Challenges of the Pandemic

Library	Programming during the pandemic
Fort Worth Public Library	virtual Spanish classes addition of 3,000 digital titles in English and Spanish phone calls to library cardholders age 65+
Plano Public Library	livestream programming on Facebook (story time, adult programs, family programs) virtual programs (book clubs, readers' advisory, ESL, collaborative nature-themed programs)
Pottsboro Area Library	drive-in Mario Kart tournament one-on-one computer assistance by appointment expansion of WIFI in nearby parking lot
Houston Public Library	e-ticket distribution to library cardholders for local taped theatre performance of Orwell's 1984
Denton Public Library	children's story time live streamed on Facebook
East View High School Library	Chromebook/hotspot distribution paperback book giveaway librarian/teacher collaboration virtual book club
Dustin Michael Sekula Memorial Library	3-D printed face shields created by staff for first responders
Cleburne Public Library	3-D printed plastic buckles (ear savers) for face shields created by staff for first responders and essential workers
Texas A&M-Corpus Christi Library	3-D printed face shields created by staff for first responders
Decatur Public Library	accurate information updates concerning COVID-19 on social media podcasts

Pflugerville Public Library	Book Buddies (one-on-one virtual story time) craft kits to go
Cedar Park Public Library	virtual reading program using Beanstack to track reading
Bonham Public Library	virtual reading program using Readsquared
Central Texas Library System	story time/live events via Facebook and Zoom

Note. Library response data (Santos, 2020)

Jones (2020) examined libraries during COVID from an economic standpoint comparing libraries' responses and challenges to prior economic events. Jones asserted that libraries have been affected in terms of people, place, and platform. As a result, libraries have responded by expanding digital content and WIFI, creating online programs such as story time and adult lectures. Jones proposed that library roles should shift as the pandemic continues.

Overview of Library Reopening Guidance

During the pandemic, state and city governments issued guidance for the library operations. This guidance typically was laid out in phases. While the guidance referenced CDC recommendations, there was some variance among plans. Currently, libraries have not fully opened to pre-pandemic functionality. The following sections detail the operation plans for three regions of the country. The Colorado Department of Public Health and the Environment, the Colorado State Library, the Colorado Department of Education, and the Colorado Governor's Office issued joint recommendations detailing how Colorado public libraries should respond based on the level of incidence of COVID-19 in the communities surrounding public libraries (Colorado Department of Education,

2020). In Ohio, the Ohio Library Council's released a reopening plan which is aligned with the Centers for Disease Control's (CDC) and Ohio Department of Health's (ODH) guidance. In the District of Columbia (DC), Mayor Murial Bowser issued guidance in conjunction with DC Health and in response to recommendations from the ReOpen DC Advisory Group (Government of the District of Columbia, 2021). In response to events in DC, Bowser paused the reopening at the Phase Two level for the period from December 23, 2020, to January 15, 2021 (District of Columbia Office of the Mayor, 2020), and later extended the pause into January 23, 2021 (District of Columbia Office of the Mayor, 2021). The reopening guidelines for Colorado, Ohio, and the District of Columbia are included in Table 2.2.

Table 2.2. Overview of Reopening Guidelines for Colorado, Ohio, and District of Columbia

Location	Governing Organizations	Reopening Guidance/Phases
Colorado	Colorado Department of Public Health and the Environment Colorado State Library Colorado Department of Education Colorado Governor's Office	Stay at home (high incidence): library facilities closed, remote services only operational, and remote working maximized. Safer at home (mid-incidence) continued remote services limited walk-up services by-appointment-only services limited capacity in-person services (computer use, browsing) with social distancing and masking compliance with state/local health orders. Protect our neighbors (low incidence). in-person building access up to 50% capacity continuance of remote services and by-appointment-only services tight adherence to cleaning and sanitization protocols including quarantining of materials patron browsing with social distancing/masking increased furniture options limited staff (Colorado Department of Education, 2020)
Ohio	Ohio Library Council Centers for Disease Control (CDC) Ohio Department of Health (ODH)	Focus on physical use of the facilities/materials. (a) Phase one: Building closed to public & staff no services focused on preparation activities review of guidelines, purchase of supplies/PPE, and review of contracts for eventual reopening (b) Phase two: Building closed to public/staff in building

		staff in the building delivering curbside/drive-through services protocols focused on employee hygiene activities to limit employee interaction (c) Phase three: Staff in building & building open to public w/limited services public access for specific reasons limited capacity extensive cleaning of equipment (computers) after use emphasized closure for deep cleaning contactless pickup of materials, social distancing, and masking. (d) Phase four: Building open to public & staff with regular services full opening reopening may not be identical to pre-COVID procedures protocols to be determined (Ohio Library Council, 2020)
District of Columbia	Mayor Murial Bowser DC Health ReOpen DC Advisory Group	Phase one (beginning May 29, 2020) curbside/contactless services Phase two (beginning June 29, 2020) included patron access to the libraries at 50% capacity limited services including material returns, book checkout, printing pickup, account management, and by-appointment computer use prohibited collection browsing, use of study tables meeting/study rooms, use of print periodicals, and in-person programming Phase three maintains Phase two guidelines expands patron access to 75% capacity with limited use of study and lounge areas increased printing options limited in-person programming

> Individual libraries will phase-in services as determined by pre-determined grouping in the plan.
>
> (District of Columbia Public Library, 2020)

Conceptual Framework

The literature review revealed common elements associated with makerspaces as well as issues related to the pandemic—*makerspace staff, physical setting, collaboration, technologies, activities, makers, government mandates, reopening guidance*. I incorporated these items in the *Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* in Figure 2.1. I placed *government mandates* at the center because the mandates seemed to influence all of the other elements. Next, I wondered how patrons would access the physical space and the technologies. I considered how makerspaces would operate with the imposed mandates. I thought about how the teaching and learning activities described in the literature review might continue during the pandemic. I questioned how makerspace staff would teach and how makers would engage in learning activities. Therefore, I added the terms *access, operations, teaching,* and *learning* to the large circles surrounding the common elements. Thus, the literature review was foundational in the creation of the conceptual framework.

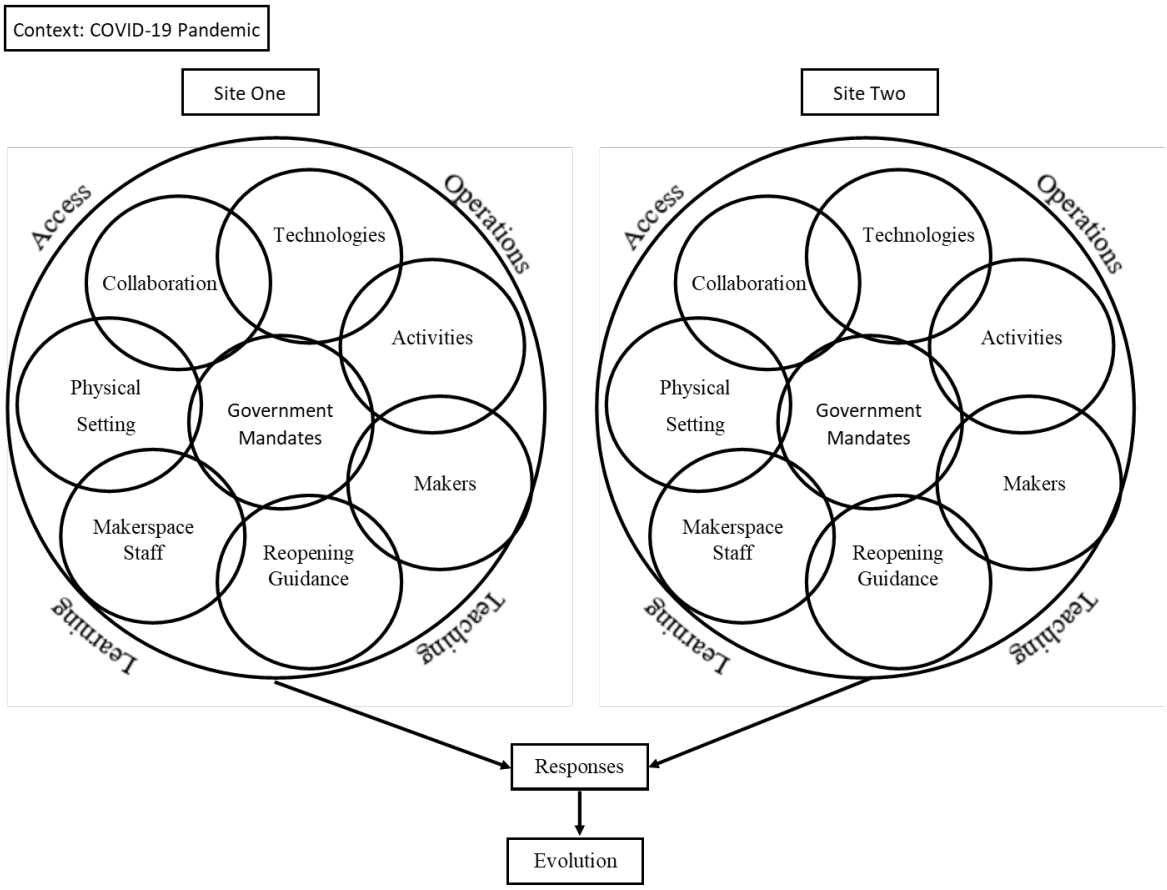

Figure 2.1. Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces

Chapter Summary

A review of the literature revealed that makerspaces, places where people make things, operate in a variety of settings. They are increasing in number and have several different names (fab labs, studios, etc.) depending on the activities that occur within them. They can operate as part of the public library system which has routinely made technology available to accommodate needs for patrons of all age ranges and ability levels. A 3D printer is a popular piece of equipment in library makerspaces, yet equipment varies from low-tech materials to machinery to studio equipment. Physical size of makerspaces varied from one room to an entire floor as do technologies and activities. Collaboration occurred in the makerspaces among the makers themselves,

through maker faires. in the surrounding community, and with grant funding. Makerspaces have faced challenges including their emergent nature, professional development, funding, accessibility, and integration with education. The COVID-19 pandemic which has affected libraries across the entire country in various ways in the form of government shut-downs and/or restrictions beginning in March 2020 has also affected the makerspaces contained within them. Plans were established for gradual reopening with some libraries offering remote, online services even during shutdown. Government guidelines provided structure for library reopenings. The literature review provided the foundation for the study's conceptual framework.

CHAPTER THREE: METHODS

Reacting to the COVID-19 pandemic, state governors issued orders that shutdown and/or reduced access to nonessential services and business including libraries which housed makerspaces. Government guidelines issued for various phases of reopening included stipulations about social distancing, capacity limits, and sanitization--ideas which are not harmonious with makerspace ideals of community, collaboration, and sharing. The purpose of this multi-case, descriptive case study is to describe how makerspace leaders have already adapted and continue to press on to adapt their environments in the context of the COVID-19 pandemic, an unprecedented challenge. By studying two public library makerspaces, I examined the effects of the pandemic on the access and operations of the individual makerspaces, identified common and unique responses, and provided some insight into how makerspaces might evolve as a result of the examples of makerspace leaders' responses and actions. Leaders who may still be in the reopening phase or facing a similar challenge could also benefit from this empirical study.

Research Questions

Drawing from the elements in the literature review as well as my experience, I crafted the research questions to illustrate the boundaries, reflect the problem, serve as an organizational tool, and foreshadow the course of the study (Onwuegbuzie & Leech, 2006). The research questions for this study are as follows:

RQ1: How has the pandemic affected makerspace access and operations, and the teaching and the learning that occurs there?

RQ2: How have makerspace leaders responded to the challenges of the pandemic?

RQ3: How have makerspaces evolved during the COVID-19 pandemic?

Research Design

Yin (2014) identified case study as an advantageous method for researchers who have how/why questions and are exploring a contemporary event over which they have little or no control. Literature focused on both case-study research and qualitative research emphasized the need for rich, detailed data and reports that include thick descriptions (Creswell, 2013; Flyvbjerg, 2007; Merriam, 2009; Miles et al., 2020; Stake, 2000; Yin, 2013). Other common elements include frequent/extended contact with participants in their settings, a holistic analysis of context, inclusion of participant perceptions, role of researcher as data collection instrument, analysis of words, goals of descriptions and explanations of participants' interactions with their settings (Creswell, 2013; Miles et al., 2020). Therefore, case-study research is primarily qualitative research.

I used descriptive case study design for this research. The descriptive case study is the preferred method for researchers who plan to focus on "how" or "why" questions, and contemporary events in a setting in which they have little or no control over the case events (Yin, 2014). Case study design is appropriate for this research because the research questions are "how" questions. As I created the conceptual framework and considered how the context would influence the sites, "how" questions came to my mind instinctively. The contemporary nature of the context--the ongoing COVID-19 pandemic-

-is also makes case study a good fit. As the researcher, I had no control over the length or intensity of the context, nor did I have control over the activities and operations in the makerspaces being studied or the decisions of the leaders managing the spaces. Researchers who used descriptive case study strived to describe the phenomena, the case, in terms of its real-life context (Baxter & Jack, 2015; Yin, 2014). My goal in this study was to describe the phenomena, the public library makerspace, in its real-life context of the COVID-19 pandemic. The concepts that emerged through the formation of the conceptual framework provided a basis for the description. This study was conducted virtually which was unique and appropriate because makerspaces were functioning virtually and/or with limited physical access. Jameson-Ellsmore (2021) described the use of virtual methods, similar to those used in this study, to conduct dissertation research during the pandemic. Therefore, this research design met standard recommendations and was suitable for this study.

Case-study researchers focus on one or more cases (Creswell, 2013; Merriam, 2009; Simons, 2009; Stake, 1995; Yin, 2013, 2014). The study included two research sites, making it a multi-case descriptive case study. I conducted this study during the COVID-19 pandemic which was ongoing at the writing of the dissertation. Therefore, I included descriptions for the pre-COVID and COVID contexts. I explored within each case in terms of the makerspace operations and access in terms of three phases: pre-pandemic, pandemic (physical makerspace not accessible to patrons), and reopening (physical makerspace accessible to patrons in some capacity). The pandemic's ending remains indefinite; therefore, the study's reopening phase occurred as the pandemic

continued. I examined the data across the cases to identify commonalities and differences in the phenomena.

Researcher Bias

Several years ago, I attended a maker faire hosted in a public library. The library's makerspace was extensive with a variety of equipment, plenty of space, and several staff members who were willing to teach and assist patrons. This was my introduction into makerspaces. As a high school teacher/librarian, I began to think about how my students could benefit from such a space, and I started one with a single 3D printer and a handful of curious students. Over time, the technologies in my school's makerspace have expanded to include five 3D printers, a laser cutter, a vinyl cutter, several varieties of robots, and other equipment as well as dedicated time in the schedule for students and staff to access the equipment in the library. I referred to that public library makerspace often over the years as I developed the makerspace in my school library. The operations of my high school makerspace were nearly halted during the pandemic as access was limited, equipment sharing was not permitted, and virtual learning was prevalent. Because I wasn't sure how to proceed when faced with the limitations resulting from the pandemic in my school, I sought to fill a gap in my own experience by conducting this research.

Since the onset of the COVID-19 pandemic, many other makerspaces have also experienced an interruption in access and service. In September 2020, I participated in a virtual Nation of Makers (2020) Ask Me Anything meeting where library makerspace leaders discussed concerns and strategies surrounding reopening plans. I expected that established makerspace leaders such as these would have valuable ideas about carrying

the makerspace through the pandemic. Makerspace staff at one of the sites used for this study were recognized as leaders to watch by a national library publication. Therefore, I expected these leaders to be experts in the field who could provide me with ideas and strategies that I could apply to my school library.

Sample of the Study

Merriam (2009), Mills et al. (2010), Simons (2009), and Stake (1995) called for case studies to include cases that are particularistic, meaning that they are focused on a specific event, person, group, or issue. I chose cases for this study that are focused on public library makerspaces affected by the COVID-19 pandemic, and conducted the study virtually by examining each makerspace's own setting. Using purposive, convenience sampling, I searched for potential case sites by conducting internet searches, joining makerspace groups on social media, and attending virtual events for makerspace leaders. I collected contact information for makerspace leaders and sites who met the predetermined criteria and emailed them to inquire about their makerspaces. Ten leaders responded, and some agreed to meet via teleconferencing. After communicating with all of the leaders who responded, two sites stood out to me for their leaders' determination to respond to the challenge of the pandemic by both following the governmental guidelines which led to offering limited virtual services and reinventing the activities/procedures of the space after reopening physical spaces to patrons. The sites also differed in their focus (fabrication lab vs. preservation/studio/fabrication space), which allowed me to study two sites that offered different makerspace services.

Selecting accessible sites where a researcher can establish a good rapport with the participants is important (Creswell, 2013). To that end, I had conversations via email and

teleconference with the makerspace leaders of these two sites throughout the pandemic. Criteria for case consideration included (a) a public library makerspace setting that was established and active prior to March 2020, and (b) makerspace leaders who are willing to share their experiences concerning the effects of COVID-19 on their makerspaces. Both of the case sites meet these criteria.

Site One

The Site One makerspace is located in a western city in a mountainous region of the United States. It is home to the main campus of a large university. The U.S. Census Bureau (2020) reported an estimated population of 105,700 people with 87.4% white, 5.8% Asian, 3.8% two or more races, 1.2% black or African American, and 9.7% Hispanic for this city. The median age of the population was 28.6 years, younger than the national average of 38.4, likely due to the university setting. The median income was $69,500 and the median property value is $700,000. Educationally, 96.9% of the population had a high school diploma with 76% having earned a bachelor's degree or higher. The library received municipal funding tied to the city's sales tax, but it was preparing a campaign for the formation of a library district to be placed on the November 2022 ballot. Prior to the COVID-19 pandemic, the makerspace staff was made of 3.5 fulltime staff members with backgrounds in engineering and architecture. Technologies in the makerspaces included 3D printers, CNC machine, Epilog laser cutters, sewing machines, vinyl cutter, looms, electronics, woodworking tools, computer with various types of software. The makerspace at this site was primarily a fabrication lab.

The Site One makerspace was established in 2016. For their work involving community partnerships, support of local business, and makerspace events, the Site One

makerspace staff were recognized as leaders who influence the future of libraries. They delivered a keynote conference presentation during which they highlighted their makerspace programs which mainly focused in fabrication (e.g., 3D printing, laser cutting, sewing, welding, woodworking). The leaders' experience, recognition for innovation, and willingness to share their experiences, as well as the space's unique fabrication focus, led me to believe that this site was a place where I could maximize learning concerning shifts in makerspaces during the pandemic.

Site Two

The Site Two makerspace is located in public library in the mid-Atlantic region of the United States. The city is a center of government and rich with history. According to U.S. Census Bureau (2020) population estimates (V2021), the city's estimated population was 105,673 with a racial representation of 87.4% Caucasian, 5.8% Asian, 3.8 % of two or more races, 1.2% Black or African American. Of all the races, 9.7% was Hispanic. Nearly 97% of the population had a high school diploma, and 76% had a bachelor's degree or higher. The median age of the population is reported as 34.3, close to the national average of 38.4. The median income was reportedly $86,420 with the median property value at $601,500. The makerspace received funding from city government and grants. The staff consisted of ten members. Site Two included three distinct labs which offered separate spaces for fabrication, digitization of audio/visual files and documents, and audio/video recording and editing. The makerspace labs were temporarily housed in three separate locations awaiting the renovation of the main library. After the renovation, the labs were to reunite in a common space in the main library.

The Site Two makerspace was established in 2013 with a single 3D printer. Prior to the pandemic, the makerspace was split into three temporary locations at neighborhood branches while the main library experienced major renovations. The makerspace returned to the main library in August 2020. The makerspace includes a memory lab for digitizing photos, slides, and home movies; a fabrication lab with sewing machines, laser cutters, and a tool library; and a multimedia studio lab for creating and editing audio, video, dance, and photography. The Site Two makerspace staff consists of a supervisory librarian and several staff members who were trained or self-taught to use and maintain the equipment. Because of its diverse equipment and programming options as well as the completion of a significant renovation for the makerspace, Site Two appeared to be a site where I could learn about the effects of the pandemic on a library makerspace.

Although each case met the criteria for this study, the cases differed in their equipment, program offerings, and leadership. Site One is primarily a fabrication lab led by engineers and an educational technologist. Site Two, whose leader has a background in library science, offered multiple studio experiences and preservation labs in addition to some fabrication equipment. The events for each makerspace reflected these differences. The variations at the two sites offer a broader range for study than just one case alone would provide.

Data Collection

Researchers agree that a case study must include multiple types of data collection (Creswell, 2013; Merriam, 2009; Simons, 2009; Stake, 1995; Yin, 2014). Using a variety of data types with overlapping evidence helps to strengthen the study (Yin, 2014) and

corroborate data collected from another source. Table 3.1 lists the type of data recommended by researchers.

Table 3.1. Recommended Data Types for Qualitative Studies

Data Type	Source
interviews observations documents	Creswell, 2013; Simons, 2009; Stake, 1995; Yin, 2014
archival records physical artifacts	Yin, 2014
audiovisual materials	Stake, 1995

Before I began data collection, I thought about what data types might be valuable in providing data about the elements that I had included on my conceptual framework. For example, I considered who or what might provide data that would describe the physical setting. I expected that staff members might describe the setting and that field observations would be a way for me to verify their description. Likewise, I thought about appropriate data sources for information about the implementation of activities in the makerspace during the pandemic. I decided that the staff and patrons as well as online calendars might provide that information. In the end, I included all of the recommended data types as listed in Table 3.1.

For this case study, I collected data from the following sources: (a) virtual interviews of makerspace staff, library director, and makerspace users; (b) virtual field observations including tours and programs; (c) websites (makerspace, library, state/city government); (d) library/makerspace policy documents; (e) state/city government documents; (f) public videos; (g) program brochures/web pages; (h) makerspace/library social media accounts; and (i) correspondence (memo, brochures, email). Because there

is not a standard of organizing and operating a makerspace, the number of data sources varied between cases. Table 3.2 lists the data sources that I used to collect information about each research question. I used some sources (i.e., virtual interviews) to gain information to support more than one research question. I aligned each interview question with a particular research question.

Table 3.2. Alignment of Research Questions to Data Sources

Research Questions	Data Sources
RQ1: How has the pandemic affected makerspace access and operations, and teaching and the learning that occurs there?	Virtual interviews Virtual field observations (tours) Website pages Library policy documents State/local government documents Program brochures Social media accounts Public videos
RQ2: How have makerspace leaders responded to the challenges of the pandemic?	Virtual interviews Social media postings Correspondence Public videos
RQ3: How have makerspaces evolved during the COVID-19 pandemic?	Virtual interviews Virtual field observations (tours) Programming brochures Library policy documents Website pages Social media accounts

During data collection, I assumed the role as primary data instrument. In such a role, the researcher collects data through means such as interviewing and observation, a concept that is consistent with other qualitative research methods (Merriam, 2009). This means that the researcher is the actual device through which data is acquired and

recorded. This study was conducted virtually because of the ongoing limited access to the makerspaces. Although I requested interviews with the makerspace staff members and patrons, only the primary makerspace staff member at each site agree to be interviewed. I interviewed one makerspace leader from each site and conducted observations virtually. At times, the researcher actually becomes part of the context such as assuming the role of participant-observer and taking part in the activities being studied (Yin, 2014). As a participant-observer, I participated in virtual synchronous and asynchronous events that the makerspaces offered. In case-study, the researcher develops protocols and forms on which to record the data during time in the field, and makes decisions about what data to collect (Creswell, 2013). Later, this subjectivity is part of the framing; it is essential for understanding and interpreting the data with the intent of reaching deep understanding (Simons, 2009).

Interview Data

Interviews followed an interview protocol based on researchers' recommendations, but also included in-the-moment questions in conjunction with emergent topics (Creswell, 2013; Merriam, 2009; Miles et al., 2020; Stake, 1995). A prepared interview protocol helped me to maintain my focus during the interview so that I addressed the topics of my research questions systematically and completely.

I interviewed the Site One makerspace leader two times. The first interview lasted 33 minutes. I conducted a second follow-up interview to include the reflection questions and clarify information from the first interview. The second interview lasted 23 minutes. I interviewed the Site Two makerspace leader once with the interview lasting an hour and 28 minutes. This interview included all of the reflection questions. During the interviews,

I probed for information concerning the elements on the conceptual framework. In-the-moment questions allowed me to avoid a rigid study and instead allowed the cases to be represented realistically. Figure 3.1 shows the sample interview protocol that I used as a guide for each interview.

Interview Questions – Makerspace Employee
Date: Time: Interviewee: Role of interviewee:
Thank you for participating in this project. Would you please describe your role in the makerspace? This research is concerned with the functions of public library makerspaces and the instruction/learning that takes place in them. Would you describe what the makerspace was like before March 2020—before the COVID-19 pandemic? *Probes:* _____ What did the makerspace look like at that time? _____ What kind of activities took place? _____ How did users learn to make their products and use the equipment? _____ How did they engage with each other, with employees, and with the equipment? What changes took place in the makerspace when the COVID-19 pandemic first began and then continued into 2021? (RQ2) *Probes:* _____ What were the initial changes or reactions? _____ How did the reactions/activities shift as the pandemic continued? _____ What services, if any, were offered during the pandemic and how were they offered? _____ What kinds of conversations occurred among leaders and staff concerning the makerspace as the pandemic persisted? _____ What unique challenges did you face and how did you respond? Has the makerspace reopened to in-person users? If not, to what extent is it open, or what are the plans for reopening to in-person users?

Can you describe how the makerspace looks today? (RQ3)

Probes:

_____ What does the makerspace currently look like?
_____ What kind of activities are taking place?
_____ How are users learning to make their products and use the equipment?
_____ How are they engaging with each other, with employees, and with the equipment?
_____ How is the makerspace environment different than it was before the pandemic started?

Are there any challenges that you as a [insert role] continue to encounter in the makerspace? (RQ3)

How do you expect the makerspace to function going forward? (RQ3)

How do you think the conditions under which makerspace had to operate during the pandemic impact the operations and learning? (RQ1)

Reflection Questions:

What have you learned from managing the makerspace during the pandemic situation?
What would you do differently, if anything?

Note. Adapted from Miles, M. B., and Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). SAGE.

Figure 3.1. Interview Protocol for Makerspace Employees

The interviews were recorded via video conferencing software (virtual interview). I copied the auto-generated transcripts and then applied pragmatic transcription to produce a verbatim script (Evers, 2011). Both transcripts and interview audio and/or video files were uploaded into NVivo qualitative data analysis software. The interviewed makerspace leaders granted me permission to interview makerspace staff ; however, no other staff in either case agreed to be interviewed.

Field Data

I collected field data through virtual programming observations and tours which consisted of public videos and transcripts. Merriam (2009) recommended that researchers observe and take field notes on the physical setting, the participants, activities and interactions, conversations, subtle factors (i.e., unplanned activities, nonverbal communication, what is missing/not happening), and the researcher's own behavior. I toured each site according to their preference: either virtually or accessing a public virtual tour. Field data from the virtual tours consisted of video recordings and transcripts. Additionally, field data included public recordings of both maker sessions and live programs as these artifacts represent the interactions of the makerspaces while they were closed. Through field observations, I gained (a) a comprehensive view of the site and the setting, (b) an opportunity for detailed descriptions, (c) an idea of institution's norms and values, (d) a way to collect data from participants who are inarticulate in interviews, and (e) a way to confirm data collected in another form (such as interview) (Simons, 2009). I uploaded the videos using the NCapture feature into NVivo, then applied pragmatic transcription to the auto-generated transcripts to produce a verbatim transcript. Some videos were captured and uploaded into a transcript-generating software to create a verbatim transcript. Then I uploaded the transcripts into NVivo. In addition to interview and observation data, I collected data from publicly accessible websites and documents such as makerspace/library website pages, state/local government documents including health orders, and social media accounts. I captured this data using NCapture for NVivo or Freemake Video Downloader, a software for saving online videos. I uploaded videos without an available transcript into Descript, a transcript creation software to generate a

verbatim transcript. The examination of documents was used to identify topics of further investigation or to verify claims (Yin, 2014). All were uploaded these data into NVivo QDAS for analysis.and uploaded into the NVivo software. I used documents to identify topics of further investigation or to verify claims (Yin, 2014).

Data Reflection

I practiced reflective journaling after data collection and transcription to reflect on the data. Ortlipp (2008) advocated for the use of reflective journaling for researchers to develop a critical perspective of their practices in order to create transparency and affect research design. By journaling, I transcribed my thoughts and connected them to literature in order to identify connections, and to examine and improve my practices and decisions regarding my study (Watt, 2007). Additionally, journaling throughout the process assisted me with recording details including rich descriptions for later use in my report as Watt suggested.

Data Management and Analysis

I used NVivo QDAS for data management and analysis. I uploaded data into NVivo QDAS, and stored files on an external hard drive and on a dedicated server at Boise State University to preserve data. Interview (both audio and video) data were labeled according to the site. Files were named using standard naming conventions. I used the following additional software as needed to convert and manage the data: Microsoft Word, Excel, Adobe DC, Publisher, Descript, and Freemake Video Downloader.

Ethics

Throughout this qualitative study, I considered several ethical issues: (1) the necessity of informed consent, (2) harm and risk to those involved, (3) private vs. public information, and (4) data ownership and access (Creswell, 2013; Miles et al., 2020; Sugiura et al., 2017). Per Boise State University Office of Research Compliance Institutional Review Board (BSU IRB) (2021) guidelines, I prepared and received informed consent from each of the participating interviewees as well as the participating institutions. The informed consent form for this study was based on the basic informed consent form found on the BSU IRB website. The form outlined the purpose and background, procedures, risks, benefits, confidentiality, compensation, and participation (BSU IRB). Every effort was made to protect the individuals in the study and their institutions. I conducted member checks in an effort to be transparent and to check validity (Miles et al., 2020; Stake, 2000). To clarify data, I communicated via email with the participants that I had interviewed several times after the interviews. I conducted a follow-up interview with one interviewee to gain and clarify data. I emailed the interview transcripts to the interviewees so that they had an opportunity to add or retract information. None responded with additions or retractions. Upon publication of the formal study, I will email a copy of the final study. Attia and Edge (2017) emphasized the importance of accurate data reporting without harming professional relationships. As a researcher and a makerspace librarian myself, I followed this advice in order to strengthen relationships with other makerspace librarians while creating a reputable study.

Data Analysis

I used qualitative coding procedures to analyze the data. Miles et al. (2020) emphasized that "coding *is* analysis" (p. 63, emphasis in original). Researchers use labels, or codes, to condense, categorize, and understand the collected data to identify patterns that ultimately reveal emerging themes (Miles et al., 2020; Stake, 1995, 2000). Chenail (2012) identified coding as a way for researchers to understand, to engage with, and to ultimately report their findings. Such a process is reflective and iterative (Chenail, 2012; Merriam, 2009; Simons, 2009; Stake, 2000).

There are no definite rules for qualitative coding (Elliott, 2018). Researchers must decide based on their collected data the best way to determine data units and types of codes to use for coding (Elliott, 2018). Data units can range from individual words to entire pages of text (Miles et al., 2020). Chenail (2012) suggested reading line-by-line but focusing on meaningful units which could vary in length. The literature identified several types of coding that might be used for analysis (Elliott, 2018; Miles et al., 2020).

Saldaña (2021) recommended using descriptive coding sparingly and instead, suggested that verbs, gerunds, and the participants' own language may be more meaningful and reveal more about the human condition. Corbin and Strauss (2015) deemed process coding appropriate for all qualitative studies. In this type of coding, a researcher assigns codes that begin with gerunds which assists the researcher in identifying the steps in the process that is being studied. Corbin and Strauss identified process coding as useful in studying routines and rituals of human life, including cycles of action or interaction for meeting a goal or problem solving. Process coding is

appropriate for this study because the activities of makerspace leaders and users are representative of these types of cycles.

During this first cycle, I incorporated both descriptive and process codes. I chunked data meaningfully by interview question for coding. I used a variety of unit sizes depending on the data. For example, because the interview responses are open-ended, I coded them by sentence or by paragraph, depending on the response of each person.

The size of data units varied from phrases to complete sentences to a paragraph in length. At first, I coded everything in the videos and interviews, even attempting to code the entirety of webpage data (calendars, etc.). This was overwhelming. Saldaña (2021) advised to "Code smart, not hard" (p. 28), so I began focusing on the data related to the stated research questions. I examined the codebook list of 132 codes that I had assigned to the data units. Using the coding stripes feature in NVivo, I refocused and condensed my codes to both reduce the number of codes by grouping similar codes together.

One site produced a series of instructional videos to which I assigned process codes. Saldaña (2021) suggested that researchers examine the codes and make a numbered or bulleted list to represent the steps of the processes. Therefore, I began to group codes by processes. Table 3.3 contains a list of sample process codes that I initially assigned to data units in the transcripts from the instructional videos.

Table 3.3. Sample Process Codes Used for Coding Instructional Videos

Welcoming viewers/introducing instructor
Stating objectives/overview of topic
Providing content
Breaking down complex processes
Using examples/Illustrating with analogies or metaphors
Using concurrent video demonstration with audio explanation
Incorporating humor
Identifying next steps
Encouraging contact with makerspace
Crediting funding sources

I continued with the process coding technique as much as possible. I included descriptive codes and in vivo coding when process coding did not seem applicable. The in vivo codes seem most appropriate when the participants used unique names for their own products or processes. Miles et al. (2020) deemed in vivo coding to be appropriate for honoring the participant's voice. For second-cycle coding and beyond, I revisited the data, grouping like data into one code when appropriate. I also renamed codes as I continued to consider meaning. As I coded, I wrote notes and thoughts that occurred to me in my research journal for future consideration. I continued coding and writing until I was satisfied that the process was saturated.

Using NVivo for Data Analysis

Several QDAS packages are available to assist researchers in their qualitative research with various features available in each package (Melgar-Estrada & Koolen, 2018; Silver & Patashnick, 2011). For this project, I used NVivo QDAS for the process of data storage, exploration, and analysis. NVivo supports all of the data types that I used for this study, and it provided tools for coding, annotation, memoing, visualization, and analysis that I need and know how to use. For this analysis, I used emergent codes as I analyzed the data.

Following Creswell's (2013) warnings to not limit data collection to predetermined coding and Blair's (2015) recommendation to develop appropriate coding tools, I relied upon emergent codes. These codes can take on various forms, and researchers have offered many suggestions regarding pattern types including in vivo codes, process codes, concept codes, emotion codes (Creswell, 2013; Elliott, 2018; Miles et al., 2020).

I used both first and second cycle coding, also known as descriptive and pattern coding (Elliott, 2018; Miles et al., 2020). Once I read through the entirety of the data, I read through it again more slowly and purposefully, pausing to consider the process being described. Although labeled "first cycle," the coding process actually involved several iterations as I worked. Throughout the coding process, researchers must focus on and analyze emerging themes, a practice which requires flexibility as well as cyclical, iterative, inductive and deductive analysis (Miles et al., 2020). I used a constant comparative method to continue revisiting the data in an effort to continue to reduce and recode it in an iterative and complete manner as Fram (2013) described. When satisfied

that I had reached the saturation point, I examined the assigned descriptive codes for patterns (i.e., second cycle coding) to combine codes that may be similar or better suited as sub codes.

Because this study included two cases, I used within-case analysis to focus on each individual case in its own context in an effort to describe, understand, and explain it as Miles et al. (2020) suggested. Then, I used between-case analysis to compare cases using a case-oriented approach (Miles et al., 2020). For example, I collected, transcribed, and coded data for Site One. After performing both 1st and 2nd cycle coding, I repeated the process for Site Two. Once cases have been analyzed separately, I examined the data for commonalities.

In NVivo, a memo is the place for researchers to journal their thoughts and questions as they arise throughout the research (Jackson & Bazeley, 2019). Memoing keeps researchers' ideas separate from the collected data which avoids contamination and confusion (Jackson & Bazeley, 2019; Miles et al., 2020). Through memos, researchers can search for meaning in their data, keep a record of perspectives, document decisions and rationales, and create an audit trail (Birks et al., 2008; Miles et al., 2020). In NVivo, these memos can be linked to specific nodes, cases, or files. I used memoing in conjunction with my own research journal notes. Figure 3.2 is a screen capture of a sample memo.

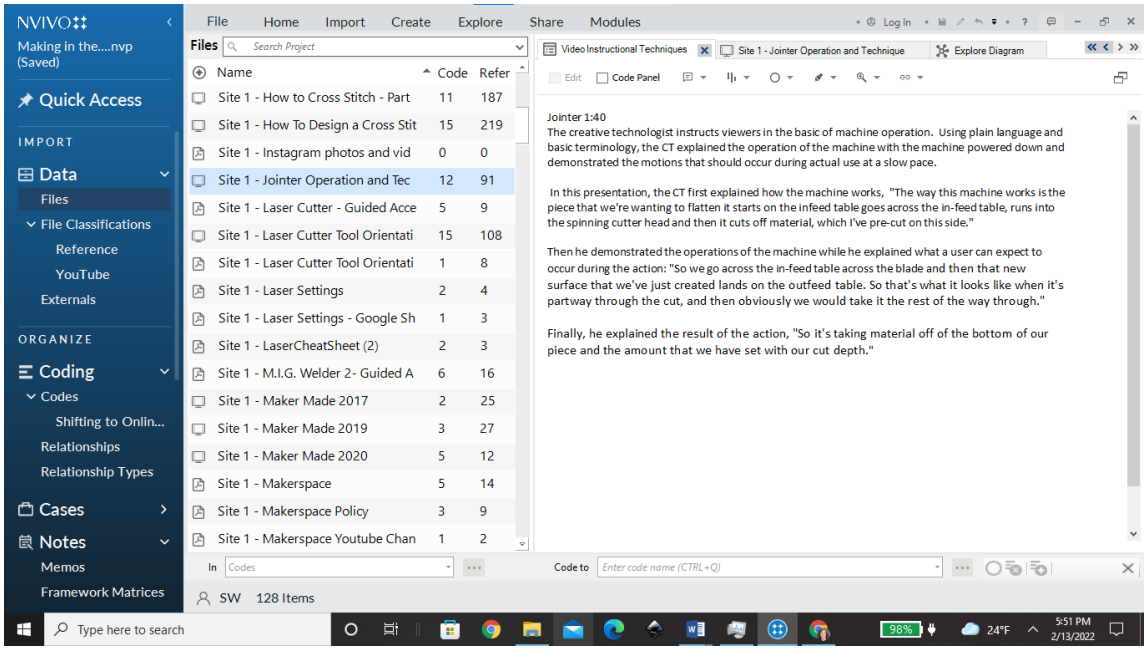

Figure 3.2. Sample memo in NVivo linked to an instructional video.

Together with the research journal, memoing provided a place to record connections and other ideas as they arose during analysis. These were helpful to me as I wrote the descriptive report.

Trustworthiness

Lincoln and Guba (1985) used four terms--*credibility*, *transferability*, *dependability*, and *confirmability*—to explain how researchers using naturalistic inquiry methods can establish trustworthiness.

They described five techniques for building credibility: (a) activities (prolonged engagement, persistent observation, and triangulation) that will lead to credible results, (b) peer debriefing, (c) negative case analysis, (d) referential adequacy, and (e) member checks. I established credibility in this study by securing long-term, regular contact with participants. This was achieved by initiating contact via email and Zoom with the makerspace leaders and inquiring about their makerspaces, thus creating rapport with them before the official research began. As the project progressed, I continued

communicating with the makerspace leaders virtually. During data collection, I emailed them to clarify data and provided them with a copy of the interview transcript. I collected data from multiple data sources for triangulation purposes. Data sources included virtual interviews and tours of the makerspaces, public videos posted on the makerspace websites and YouTube channels, website pages, documents provided by the leaders. I captured these data with audio/video recordings and cataloged the recordings using NVivo.

One goal of qualitative research is to provide a "thick description," a term which Ponterotto (2006) attributes to Denzin (1989) and Geertz (1973) among others. According to Ponterotto, the essence of thick description includes rich detail, thoughtful interpretation, and researcher reflection which together give the reader a sense of verisimilitude. This combination of elements increases the credibility and trustworthiness of the study. Miles et al. (2020) provided "practical standards" for researchers to use to determine research quality (p. 304). I referred to these standards as I conducted my study.

According to Lincoln and Guba (1985), the final two criteria of trustworthiness—dependability and credibility—can be demonstrated through a single inquiry audit. In the interest of maintaining auditability, I established an audit trail as introduced by Halpern (1983) using NVivo QDAS, Microsoft Word software, and file management. The study included all six of Halpern's audit trail categories: records of raw data, data reduction and analysis products, data reconstruction and synthesis products, process notes, materials relating to intentions and dispositions, and information development information. Specifically, I uploaded recordings, transcripts, and other raw data into NVivo where it was cataloged, reduced, analyzed and synthesized. These iterations were saved within the

software as well as memos and reflections that I generated throughout the process. Data logs within QDAS, such as NVivo in this study, promote replication and reliability for its data storage capacity and traceable analysis (Baxter & Jack, 2015; Kaefer et al., 2015). By establishing these practices, I have strengthened the trustworthiness and reliability of the study.

Timeline

The dissertation timeline in Figure 3.3 below provides a breakdown of the order and time allotted to each of the investigation activities. I used weeks 1-6 to finalize consent paperwork, make interview appointments with participants, finalize interview protocols, and revise previously submitted chapters as I awaited IRB approval. Once approval was granted, I engaged in data collection and cyclical, within-case data analysis for Site One during weeks 7-11. I collected data and used cyclical, within-case data analysis procedures for Site Two during weeks 12-16. After within-case analysis was completed for both case sites, I focused on between-case analysis which occurred concurrently in several iterations while drafting the results and the discussion. I allotted seven weeks for this phase of analysis and writing. I revised and edited with my advisor's guidance for six weeks, leaving time for thorough final review, revision, and polishing before the defense.

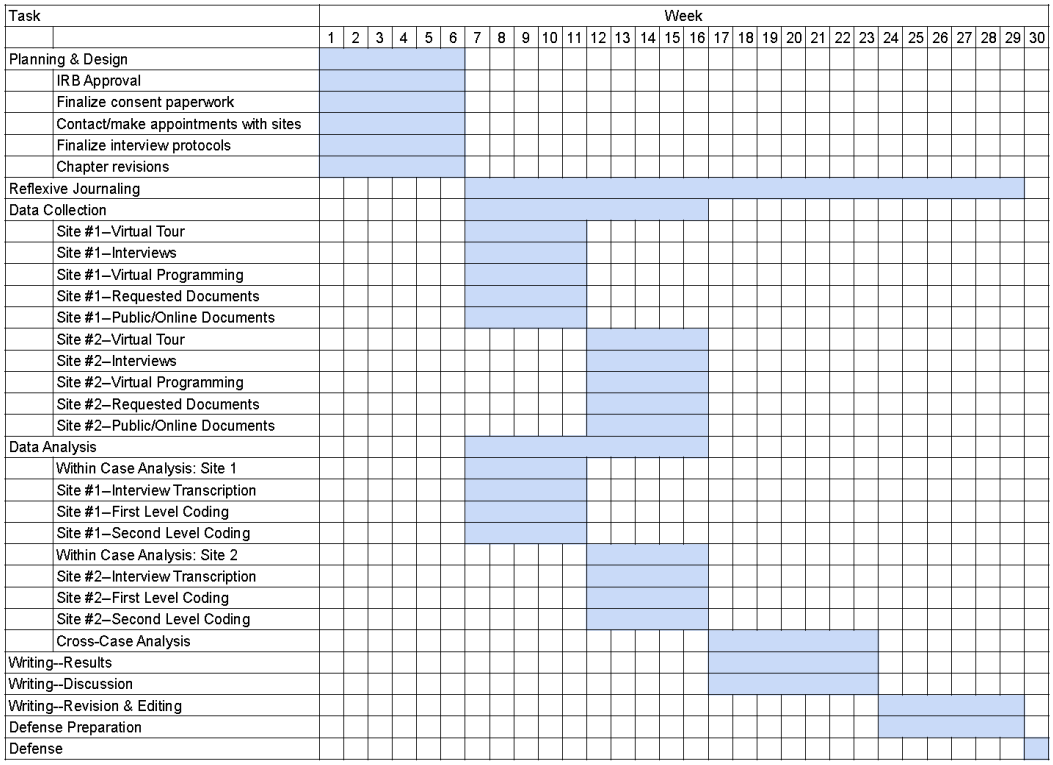

Figure 3.3. Dissertation Timeline

Chapter Summary

The purpose of this study was to examine the impact of the pandemic on the access and operations of the individual makerspaces, identify common and unique responses, and provide some insight into how makerspaces might evolve as a result of the examples of makerspace leaders' responses and actions. The method used in this research is a multi-case, descriptive case study used to describe how makerspace leaders have responded and how their makerspaces have evolved in the context of the COVID-19 pandemic. The study examined two makerspaces which differ in their equipment, offerings, leadership, geographical location, and program focus. I used the *Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* to guide the formation of my research questions and data collection. The following research

questions guided the study: (RQ1) How has the pandemic affected makerspace access, and operations, and the teaching and learning that occurs there? (RQ2) How have makerspace leaders responded to the challenges of the pandemic? and (RQ3) How have makerspaces evolved during the COVID-19 pandemic? Research sites were identified in different parts of the country. A unique feature of this study is that I conducted it virtually because at initiation of the study, both makerspaces were open to staff but closed to patrons. I collected a variety of data including interviews, virtual field observations, documents, webpages, and public videos. Data were stored and analyzed using NVivo QDAS. I used both within-case and between-case analysis, conducted several iterations of each and kept a reflective journal along the way.

CHAPTER FOUR: FINDINGS

Introduction

The purpose of this multi-case, descriptive study was to examine the impact of the pandemic on the access and operations of the individual makerspaces, identify common and unique responses, and provide some insight into how makerspaces might evolve as a result of the examples of makerspace leaders' responses and actions. The study examined two makerspaces which differ in their equipment, offerings, leadership, geographical location, and program focus. Three research questions guided the study:

(RQ1) How has the pandemic affected makerspace access, and operations, and the teaching and learning that occurs there?

(RQ2) How have makerspace leaders responded to the challenges of the pandemic?

(RQ3) How have makerspaces evolved during the COVID-19 pandemic?

I identified research sites in two different geographical areas of the United States, each restricted by state, city, and/or local health guidelines which have affected the makerspaces functionality since March 2020, the beginning of the COVID-19 pandemic. The study's data ranges from March 2020 through December 2021. Data collection occurred virtually, a unique feature for a case study. Data sets include interviews, virtual field observations, documents, webpages, and public videos. I used NVivo QDAS to store and analyze the data. I conducted both within-case and between-case analysis. In

this chapter, I present the context of both research sites followed by the within-case and cross-case analysis organized by research question.

Context

The research sites in this multi-case study are public library makerspaces that are located in two different parts of the United States. These makerspaces were established and functional prior to the COVID-19 pandemic. In this section, I have provided the context of each site.

Contextual Description of Site One

The Site One makerspace is located in public library in a city in the western United States. The city is home to the main campus of the state's a large university. The public library and makerspace received municipal funding based on the city's sales/use taxes. Interview data indicated that before the onset of the COVID-19 pandemic, the makerspace staff included 3.5 full-time members with educational and experiential backgrounds in architecture, art, design, computer science, and production (electronics, 3D printings, laser cutting, sewing, etc.). The main technologies in the makerspace included 3D printers, CNC (computer numerical control) machine, laser cutters, sewing machines, a vinyl cutter, looms, electronics, and woodworking tools.

Interview data revealed that before the COVID-19 pandemic declaration in March 2020, patrons visited the Site One Makerspace in-person in several capacities including (a) interactive, drop-in, open-studio sessions to use equipment or "passive learning" supports; (b) "guided access," one-on-one training on specific equipment with a staff member, (c) weekly/biweekly group events led by outside instructors, (d) professional development to specific audiences, (e) quarterly events/camps for educators and students,

and (f) yearly gallery events to showcase makers' projects. The staff posted videos highlighting camp and gallery events on the library's YouTube channel. Table 4.1 provides a summary of the access and operations of the Site One makerspace before the pandemic.

Table 4.1. Summary Table of Access and Operations of Site One before the Pandemic

Type of Access	Terms of Access	Equipment, Services, & Programs
In-Person	Open session (3, 7-hour weekly sessions), drop-in	Use of equipment (exceptions—laser cutters, CNC router, wood shop equipment) and supplies
	"Passive Instruction," drop-in	Self-guided tools placed throughout the space: color code guide, fabric guide, stitching guide, guide to 3D printer quality variances
	"Guided Access," by appointment	Use of laser cutters, CNC router or wood shop equipment with staff guidance
	Classes led by outside instructors, various topics; by registration	Group programs; materials/equipment vary
	Professional development; by registration	Presented to specific groups (i.e., educators)
	Camps, quarterly; by registration	Mash-up with educators/students, topic specific (i.e., space camp); materials/equipment vary
	Gallery, drop-in during event hours	Public showcase of makers' work, specified dates/times
Virtual	Asynchronous	Event videos

Contextual Description of Site Two

The Site Two makerspace is currently located in public library in the mid-Atlantic region of the United States. The city is a center of government and rich with history. The public library and makerspace contained within rely on funding from the city and grants. The makerspace was made up of three distinct labs: the fabrication lab, the studio lab, and the memory lab. In 2017, the main library which housed the labs closed for major renovations. The labs, the manager, and nine staff members were temporarily relocated at three separate sites.

Each lab had its own location, equipment, and focus. According to interview data, the fabrication lab was a small, but busy "storefront" with limited space where patrons could access the laser cutters, the 3D printers, and the sewing machines by appointment individually or in small groups. Attendance at a small group orientation was required before patrons could use the equipment. Staff members held classes to teach specific skills and /or projects. Libguides, webpages containing step-by-step operating instructions as well as additional print and online resources, provided additional self-support for fab lab users. The studio lab was relocated to a neighborhood branch library where patrons could drop in or schedule a time to use the equipment. Staff members split time performing studio lab duties and branch work. Equipment in the space included computers, cameras, and lighting kits, audio recording equipment, and audio/video editing software. The memory lab, a place with equipment to digitize analog audio and video content stored in obsolete formats, was located in another neighborhood branch library. The staff-led equipment orientation was optional. Patrons registered for individual appointments to use the memory lab equipment which included a variety of

audio/visual decks, monitors, computers, and software. Libguides provided step-by-step instructions and equipment support for memory lab users and entities wanting to build their own memory labs. The renovation was completed in 2020 (during the pandemic closure) with the labs being reunited into one makerspace at the main library. Table 4.2 provides a summary of the access and operations at the Site Two makerspace before the pandemic.

Table 4.1. Summary Table of Access and Operations of Site One before the Pandemic

Type of Access	Terms of Access	Equipment, Services, & Programs
Fabrication Lab		
In-Person	One patron per machine, by appointment	Laser cutters 3-D printers Sewing machines Hand and power tools iMac computers with creative-suite software
	Small-group required classes, by appointment	Orientation, machine certifications Instructional classes (Mending, project-specific)
Virtual		Libguides
Memory Lab		
In-Person	By appointment	8mm/Super8 film scanner AV decks (VHS, DV, audio cassette, Video8/Hi8/Digital8) CRT monitor TBC (Time-Based Corrector) A-D converter Scanner Analog & digital cables Mac computers with AV capture software Optional equipment orientations
Virtual		Libguides
Studio Lab		
In-Person	Drop-in	AV recording equipment Audio mixers Cameras Lights Green screens Audio editing software

Summary of Context

In this section, I provided the context for each of two research sites that are included in this study. The sites are located in different geographical regions of the United States, and the makerspaces differ in size, staff, and offerings. Both of the sites were established prior to and affected by the COVID-19 pandemic. I collected data from each site to examine the proposed research questions for this study. The data is presented in the next section according to research question.

Examination of Data by Research Question

This research focused on the following three research questions:

RQ1: How did the pandemic affect makerspace operations and access, and the teaching and learning that occurs there?

RQ2: How did makerspace leaders respond to the challenges of the pandemic?

RQ3: How did makerspaces evolve during the COVID-19 pandemic?

The data analysis in this section is presented in the order of research questions. For each research question, I present data from the in-case analysis for each of the case sites, and then the cross-case analysis which considers data from both cases.

Effects of the Pandemic on the Operations and Access in Makerspaces

In asking Research Question 1 (RQ1) "How did the pandemic affect makerspace operations and access, and the teaching and learning that occurs there?", I examined the data for ways that pre-pandemic access and operations were affected, if at all, once pandemic restrictions were imposed in March 2020. I considered how the makerspaces operated in terms of time and space, as well as the teaching and learning opportunities that they offered and how those opportunities were presented. I examined changes in the

ways that patrons accessed the makerspace, its equipment, and/or the teaching or learning opportunities that were offered.

RQ1: Within-Case Analysis of Site One

Site One makerspace closed to everyone—patrons and staff—in March 2020 due to public health orders issued in response to the COVID-19 pandemic. Initially, neither staff nor the public had access to the space itself. In an interview, a staff member described the initial response of the makerspace staff members twelve days after the closure as "the famous night raid" on the makerspace. Makerspace staff were permitted to return to the makerspace and take equipment that could be used at home particularly for the personal protective equipment (PPE) production. These items included at least a dozen sewing machines and 3D printers. The city government gave the makerspace staff members the option to return to work in the space in June 2020, and the staff members returned. Makerspace staff posted information and tutorials on the main library website, main library YouTube channel, and social media sites for patrons to access. Patrons had the ability to communicate with staff on the social media posts.

In July 2020, the makerspace staff held a virtual teleconference to discuss the access and operations going forward. Teaching and learning shifted to virtual platforms and included both asynchronous and synchronous delivery. The staff announced the new online calendar/registration system which was developed internally by a makerspace staff member, the beginning of the virtual guided access laser-cutting service, the upcoming staff/maker synchronous programs, and the upcoming virtual tool orientations. In October 2020, the makerspace staff added "virtual guided access" for 3D printing services. Patrons who registered for the virtual guided access received a link to a one-on-one

teleconference meeting for the purpose of receiving indivual instruction in laser cutting or 3D printing from a makerspace staff member. Staff members did the work of physically cutting or 3D printing the files that resulted from the meeting and patrons picked up the projects from designated shelves in the main library. A staff member described the process in an interview:

> It's essentially what we would do in person and what we were taking ownership of entirely was that production piece, the operation of the machine which for us is not just you [the patron] know how to use [and] you know [how to] press the buttons, it's a sort of a multi-layered experience of you know how to design a workflow, you know how to design files for efficiency, you know how to build those files and test them incrementally if they need to be. So it was really difficult for us to take, to share, that level of experience with people via Zoom. And for us, the satisfaction of doing that personally is much less than what it is to work with those people in person. So for them, it was less of a learning opportunity. For us, it was less of that satisfaction of teaching and in watching growth and seeing development firsthand.

Table 4.3 is a summary of the Site One access and operations during the pandemic when the makerspace was closed to patrons.

Table 4.3. Summary Table of Site One Access and Operations, Pandemic (Closed to Patrons)

Type of Access	Event	Leaders	Availability
Physical Access for Patrons	N/A	N/A	None
Asynchronous Virtual	Focused instruction	Makerspace Staff	Posted online Open Access
Asynchronous Virtual	Virtual show & tell	Makerspace Staff Guest Presenters	Posted online after editing Open access
Synchronous Virtual	Virtual guided access	Makerspace Staff	By registration only/link access (teleconference)
Synchronous Virtual	Virtual show & tell	Makerspace Staff Guest Presenters	Weekly/bi-weekly By registration only/link access (teleconference) Interactive for patrons via chat

RQ1: Within-Case Analysis of Site Two

Interview data indicated that the Site Two makerspace staff initially canceled classes and then closed to patrons and staff in March 2020 when the pandemic was declared. The equipment was moved back to the main library to its permanent home in the newly renovated makerspace. The area remained closed to patron in-person access even when the main library opened for patrons to browse library shelves for books and other materials in June 2020.

Interview data indicated that the staff were initially "proactive" in making cloth masks for essential library staff. The library director permitted staff members to borrow the sewing machines even though people "technically weren't allowed in the space." Interview data and audio/video data posted on the library's YouTube channel indicated that staff members created virtual events and made them accessible synchronously through teleconferencing and/or asynchronously on the channel. They used library iMacs as well as their own home equipment for the events. Interview data revealed that staff members loaned 3D printers for printing face shield brackets to a community group who requested to borrow them. The machines were made accessible to the group by arranging for pickup and placing the equipment as near to the door as possible.

A staff member reported that he and other staff members volunteered to assist other library departments temporarily during the pandemic. One volunteered to process insurance claims in the library's employment services department while he continued to check on the makerspace team members. Other staff members assisted in retrieving requested items for carryout, recording virtual story time from home, or supporting other

library departments. See Table 4.4 for a summary of the access and operations at Site Two during the pandemic while the makerspace was closed to in-person activities.

Table 4.4. Summary Table of Site Two Access and Operations, Pandemic (Closed to Patrons)

Type of Access	Event	Leaders	Availability
Physical Access for Patrons	N/A	N/A	None
Asynchronous Virtual	Instruction	Makerspace Staff	Posted online Open Access
Asynchronous Virtual	Maker presentations	Makerspace Staff Guest Presenters	Posted online after editing synchronous event Open access
Synchronous Virtual	Maker presentations	Makerspace Staff Guest Presenters	By registration only/link access (teleconference)
Synchronous Virtual	Mending workshop	Makerspace Staff	Monthly By registration only/link access (teleconference) Interactive for patrons

RQ1: Cross-Case Analysis

Both Site One and Site Two makerspaces closed for in-person access in March 2020. Although the makerspaces were closed to staff members also, lead staff members received permission from library authorities to enter the spaces in order to remove and use/distribute equipment and supplies for the purpose of creating PPE in response to the pandemic. Makerspace staff members were permitted to return to the space to work within a few months; however, no in-person access for patrons was permitted at either site until June 2021.

In each case within a few weeks of the closures, staff members at both sites released a video to teach viewers how to sew a mask. A Site One staff member reported that "our very first video instruction was how to sew a medical style mask, and that was being done at home with iPhones and whatever editing software we had available to us on our work computers." The amateur quality of the videos was apparent during observation as the video segments were focused on one set area at a time and include simple title slides and few subtitles, or none at all. A variety of background noise, screen shaking, and images as well as verbal references to apartment/home living provided evidence of the at-home setting..

These were posted to a library YouTube channel and/or website, openly accessible online without a library card, and included a webpage link with support materials. The videos shared common themes relating to instructional strategies: (a) *building community*, (b) *demonstrating the instruction*, (c) *identifying materials*, (d) *offering choices*, (e) *simplifying jargon*, (f) *giving an overview of the topic*, and (g)

elaborating. Table 4.5 includes data samples of the common instructional strategies used in the mask-making videos for both sites.

Table 4.5. Data Samples of Instructional Strategy Themes from Mask-Making Videos

Theme	Site One Data Sample	Site Two Data Sample
building community	"Hi, I'm [Staff Member 4]. I work at the [City} Library makerspace….Be kind to each other."	"Okay, friends. So thank you very much for joining me and I will see you guys next time."
demonstrating the instruction	"I'll do the other side and then I'll show you how to bleed it, so you can see that both sides are pins now, and both these sides and both sides are marked for pleats."	"And what I'm going to do is just pull, [pulls a strip of fabric] and now I have a strip the size that I need in order to make one of those fabric ties. So you'll notice that it's a little furry that's okay. Just, pull it off, cut it off as you need to."
identifying materials	"Here's some of the tools that we'll be using. I'll be using a sewing machine and iron. Pretty regularly we'll be using pins or the tailor's chalk to mark where we want our pleats along with the ruler to make sure that they're in the right place."	"So in the pattern I'm using today, it calls for 18-inch long fabric ties, four of those. And it also calls for a piece that is 16 by 8.5 inches long. So the piece of fabric that I'm using here--I'm trying not to show you the rest of my messy house--is called a fat quarter. So this piece is reliably 18 inches by 23 inches."
offering choices	"You can iron it at this point or you can do some stay stitching. It doesn't really matter, whatever makes you the most comfortable."	"This I made with some wire that I had laying around my house. But if you referenced [the] original tutorial, she definitely says that you can use a pipe cleaner instead."

simplifying jargon	"*Right sides* just means that you want the parts that you want to be facing out touching each other."	"When you are using fabric for any kind of project, but especially for something like this, you want to do something called *pre-washing* it, to just run it through your laundry machine or however you wash and dry your fabric, the same way that you're going to do after it's completed."
giving an overview of the topic	"...and today we're gonna show you how to make a mask."	"The U.S. government is suggesting that everybody wear a mask to help slow the spread. So fabric masks are not medical grade, personal protective equipment or PPE, but something is better than nothing. So in this case, the version we're going to make today actually has two layers, and it uses fabric ties instead of elastic, because it's easier to sanitize that way."
elaborating	"What I like to do when opening seams is lay it down flat, gently press it open. That seemed kind of open from the other side, so that it's really open. Then you'll flip it and press it again. That way, you're not losing any of the fabric in that seam."	"So please make sure that you take this part carefully. Okay. Don't try to, go super-fast or anything like that. Listen to your machine. And if she makes any weird noises, then definitely stop and give her a break."

As the pandemic continued, the makerspace staffs, using personal equipment and borrowed makerspace equipment at home as well as transitioning to more sophisticated equipment and techniques as time passed, created additional instructional videos covering a variety of topics that were posted online for patrons to access asynchronously. Additional accessibility features such as Spanish voiceovers (Site One) and American sign language (Site Two) were included in some videos. I identified the following common instructional themes in asynchronous instructional videos from both case sites: *giving an overview of the topic, identifying materials, elaborating, demonstrating the instruction, simplifying jargon, offering choices, building community, maintaining safety,* and *identifying next steps.* Table 4.6 contains data samples for the identified instructional strategy themes.

Table 4.6. Data Samples of Instructional Strategy Themes from Asynchronous Videos.

Theme	Site One Data Sample	Site Two Data Sample
giving an overview of the topic	"Before I go into how we use this machine, I'm going to explain how it works."	"So in today's video, I'm also going to talk about some of the tools and stuff that I'll be using as well as a basic explanation of quilting."
identifying materials	"The most common materials we see pass through the machine are plywoods, acrylic, plastic, MDF, cardboard, paper, leathers, fabric. and certain foams. The maximum thickness our 40-watt laser can consistently cut through is about three millimeter or one-eighth of an inch."	"At the very top is a TBC, which stands for time-based corrector, which helps the computer accurately represent the video signal coming from your tape. Below that is the VHS deck, which can play both regular VHS and S-VHS tapes in standard play mode. Also known as SP."
elaborating	"3D models designed by humans are turned into a set of instructions for these specialized robots to follow using what we call a slicing software."	"Now there are a couple of different methods, but weaving is basically one way that we get stuff like cotton and things like that. When you're doing sewing for apparel, you may hear even woven fabric versus knit fabric. And this is the kind of thing you're talking about."

demonstrating the instruction	"To use your needle threader, you're going to take your needle and you're going to put the wire part of the threader into your needle, and then you have this little space here and the wire that you're going to put your thread through and that space is much bigger than the eye of your needle."	"Let me show you what I mean. So I've got my stuff all lined up where I needed to be. I have my threads started and I'm just going to keep sewing. I'm letting the feed dogs grab that next piece of fabric and I'm just going to follow the line that I made."
simplifying jargon	"A slicing software does kind of what it sounds like. It takes a model and turns it into layer by layer instructions for recreating your object in the printer."	"But, yeah, so it's this really beautiful, sweet, simple pattern that uses something called a "charm pack." In some versions of quilting, you can use these things called pre-cuts. So a charm pack refers to a pack of material that is only five inches square."
offering choices	“There are more ways to get started than just two, and a simple Google search will give you more options than you really need to try. First is by just using a simple knot."	"So if you don't want to do the tucking that's okay. You could tie them in a knot, that's just fine, but you want to make sure that they're secured because if they're not, they will become, they will come undone, which is no good after all this hard work."
building community	"If it's your first time, we'll review all of the content we've covered here, and start with a nice easy practice project. You'll be welding in no time."	"We also have classes [that] we hold on other personal archiving topics like understanding and preserving your social media accounts, digital photos, home movies, and we hold screenings and other events that celebrate local communities and their history."

maintaining safety	"Let's talk about laser safety. Here are some do's and don'ts. The number one rule of laser safety is to stay with the machine at all times. Every laser disaster we've ever heard has come from someone starting the machine and walking away."	"And remember here too, this thing is called a rotary cutter because the blade is perfectly circular. So there is no part of this metal piece right here that is safe to touch. Okay. It's all one sharp edge. Great. For cutting, not so good for our fingers. So let's be careful."
identifying next steps	"If you've watched this video as part of our laser cutting tool orientation class, you are now free to sign up for guided access on our website. For questions and comments, leave them below. Thank you and keep on making."	"Please be sure to check out [website] for eBooks, audio books, puzzles games, and some really neat resources to this is actually quick shout out to one of my favorite resources, RB digital. So if you were curious about the chaining technique too, so these little squares together that came out of American Quilting, one of the quilting magazines in RB digital. Okay. So there are a couple on there. Definitely check them out because there's more tips and tricks in there. Okay. Digital resources, [website]. Okay. All right. Thank you very much once again, and I will see you guys next time."

Teleconferencing (Zoom) was the primary technology used for virtual synchronous events at both sites. Makerspace staff and guest/maker presenters joined the teleconferences with audio/video while patrons/viewers pre-registered to watch and interact via the chat (text) feature. The Site One synchronous events were informal and conversational, and focused on updates and project/maker presentations. Once the main library opened for in-person pickup service, the Site One staff offered one-on-one "virtual guided access" for a single patron registered to teleconference with a makerspace staff member to discuss, design, and email a specific project file for the 3D printer or laser cutter for makerspace staff to print. Staff left the printed items on the pickup shelf in the main library for patrons to retrieve.

The Site Two virtual synchronous events were informal and structured with a staff member hosting the event while one guest presented project experiences which sometimes included project instructions. The host read viewer questions from the chat at the end so that the guest could respond. Interview data indicated that Site Two held a monthly mending (sewing) workshop through teleconferencing for registered patrons which included audio and video interaction among participants.

Summary of the Pandemic's Effects on Operations and Access in Makerspaces

In this section, I presented data to support RQ1 by examining the data for

for ways that pre-pandemic access and operations were affected if at all by the pandemic restrictions that were imposed in March 2020. I presented data detailing how the makerspaces operated in terms of time and space, as well as the teaching and learning opportunities that they offered and how those opportunities were presented during the pandemic. I presented data that detailed changes in the ways that patrons accessed the

makerspace, its equipment, and/or the teaching or learning opportunities that were offered. The analysis includes themes that I assigned to data units as well as data samples in the analysis. In the next section, I will present the findings concerning the challenges that makerspace leaders faced during the pandemic and their responses to those challenges.

Makerspace Leaders' Response to the Challenges of the Pandemic

In asking Research Question 2 (RQ2) "How did makerspace leaders respond to the challenges of the pandemic?", I focused on challenges that arose from the pandemic situation specifically. In this analysis, I first identified the challenges for each case and then I examined the data for evidence that describes how the makerspace staff responded to the situation. Then, I analyzed the data across the two cases.

RQ2: Within-Case Analysis of Site One

Interview and video data revealed that the Site One makerspace staff faced two main challenges: (1) how to adjust to funding cuts and the resulting staff cut, and (2) how to engage with makerspace patrons amid the limitations on physical access to the space. A Site One staff member described the thinking among the staff:

> How do we engage as much as possible under the constraints, and what are the consequences if things continue to trend in a certain direction? So one of the consequences was by October [2020], we had lost a full-time staff job, and so we were reduced to two and a half, and we were still looking pretty far out at that point to reopening in-person services, and so I would say once that position was eliminated, the entire conversation became "Okay, what does this mean for our normal operation?" We just needed to reconceive normal operation.

The Site One makerspace staff responded in a variety of ways. They repurposed remaining funds into new programs and supported new funding efforts. They used teleconferencing [Zoom] to keep patrons informed of the makerspace's situation, to interact with patrons and other makers, and to provide one-on-one printing/cutting service for patrons.

Funding

The library received funding through the city government. The makerspace, as part of the public library, was included in the library's funding portion. A staff member reported that the city's budget is dependent on sales and use tax which decreased by $6 million dollars from 2019 to 2020 in part because of the city's dependence on tourism which declined during the pandemic. These budget constraints resulted in cuts citywide including the lay-off of 66 library employees. One makerspace staff member who was under a probationary period per the new-hire conditions of employment was laid off when funding was cut. A staff member described the response:

> We designed the program over the past four or five years to be just sustainable with 3.5 full-time people, okay, and so at 2.5, we've scaled back what's offered for public programming not by a third, but I would say 20% or so.

According to interview data, the makerspace staff responded by reconfiguring the calendar, specifically the woodshop access, to maximize the number of patrons who could use the equipment in the space at one time. A second response was the support of a proposal for the library to form a library district which would be funded by property tax, instead of sales tax. The staff expected the proposal to be on an upcoming voting ballot.

The second funding source, the community foundation, supported the makerspace by funding equipment and materials. Interview data, makerspace website data, and asynchronous video data refer to the community foundation's generosity and support. In an open house video providing updates for patrons, a staff member commended the community foundation:

> I was thinking of the [community] foundation who are our main benefactors. Shout out to them--all the awesome work that they've done especially over the past year to help out our fellow staff workers, and to keep us and this place running and to get it back up and running for y'all.

With community foundation support, staff members responded by repurposing funding that would have been spent on materials for the daily use of the space to instead be used to purchase additional 3D printers and MIG welding equipment.

Engaging Makers in Community

In July 2020, the makerspace staff hosted the first synchronous maker show-and-tell event via teleconference. Staff members and guest presenters used audio and video capabilities. Patrons registered for the event and participated in the chat (text). The informal, conversational event was held weekly, then biweekly from August through October 2020. The number of staff members hosting each episode varied. In one, a staff member participated as a viewer using the chat (text) only because he was on furlough from the library. The first episode revealed the following themes: (a) *following COVID health protocols,* (b) *drawing on multiple skillsets and influences,* (c) *offering virtual guided access,* and (d) *registering for online programs.* Each episode began with an update of makerspace progress, upcoming event opportunities, and thoughts about future

reopening. Then staff or guests presented projects that they had made or were making. Patrons/viewers interjected questions by typing them in the chat. These were read by staff members. After the introductory episode, data analysis revealed three recurring themes in the show-and-tell events: (1) *building community,* (2) *leading as a maker,* and (3) *sharing maker experiences.* Table 4.7 contains data samples from the three themes along with the participant source.

Table 4.7. Data Samples of Themes from Synchronous "Show-and-Tell" Events

Theme	Participant	Data Sample
Building community	Makerspace staff member	"We've got a program for you tonight. We're excited to have [makerspace staff member] showing us some cool stuff. We've got some other guests coming online, we think. Here, they haven't arrived at the backstage yet, but we are waiting for them now. What's new in maker world?"
Leading as a maker	Makerspace staff member	"In addition to being a woodworker, I paint, and I'm pretty fascinated especially with contrast. I really like to exaggerate contrast, and just in thinking about a broad range of values, I started thinking about how could I start to play with that three-dimensionally… This was my first experiment with expressing value kind of topographically so the highlights are the highest part of the topographical map if you will, and the darkest is the lowest. This one I did as an experiment before I had access to a laser cutter so I did this one on a scroll saw. "
Sharing maker experiences	Guest presenter (child)	This one is my board game. We were in the same online summer camp, so it was board games. Mine is based on Adventure Time…I still want to work more on it, so it looks better. But pretty much, you guys have to work together to get to the end, and you get to certain points, and there's scenarios.

Makerspace staff engaged with makers individually through the "virtual guided access" service. During an "open house" teleconference in June 2021, a staff member reported that 700 people participated in the service and printed/cut projects between

August 2020 and June 2021.

RQ2: Within-Case Analysis of Site Two

The Site Two makerspace leaders faced challenges in the areas of staffing, engaging with makers, and funding. They faced other challenges related to their planned return to the main library. The challenges presented here are those that interview data indicated as specific to the pandemic.

Funding the Makerspace

Prior to the pandemic and the return to the main library, the makerspace staff had anticipated that funding would be available to service and replace some makerspace equipment. According to interview data a staff member indicated that a city government "spending freeze" affected the equipment replacement plans. In response, the staff serviced and reused old makerspace equipment. The staff also responded by requesting to reallocate Library Services and Technology Act (LSTA) grant money for makerspace purchases. That request was granted.

To fund a new event opportunity, the manager reported that he worked with a nearby university to write a grant to teach librarians how to create an interactive game that focuses on local history and culture. The grant funded a two-year program that included raspberry pi units with pre-loaded software and travel stipends for librarians participating in training workshops.

Engaging with Makers

Interview data indicated that virtual events were a challenge initially because there was uncertainty surrounding the most appropriate teleconferencing software, and

city government banned the use of Zoom due to security concerns. A staff member described the situation:

> We tested out different platforms. Zoom was the best platform to teach, and even that got complicated because city government did a ban on city government using Zoom because there was some Zoom bombing that happened at schools. There was just a fear that that would happen again, so eventually we had to get a waiver to be able to use [it] given its accessibility features. That took a lot of time.

Once Zoom was approved as an acceptable teleconferencing software, staff members held structured maker presentations and weekly mending workshops. Memory lab staff members used teleconferencing to record a video on the topic of introductory digital preservation. Recordings were posted on the library's website/video page for open access, where a library card was not needed to view them.

Staffing the Makerspace

Interview data revealed that library staff were initially put on administrative leave with pay and were not expected to work because "telework" (working from home) had not been an established practice. The manger periodically checked on the staff during administrative leave to ensure health and safety. Library management and union leaders worked to define telework and clarify job duties for unionized employees. Once telework was approved, the management sought volunteers to record asynchronous events. Interview data identified some disagreement between the union board and the library management in other areas such as holding outdoor events and installing necessary software on makerspace computers. Makerspace staff responded by waiting for the designated union employee to install the software.

Staff shortages were a second personnel challenge. Interview data indicated that at least one makerspace staff member resigned and moved out of the area while another chose to shift from full-time to part-time work. Some staff members who had accrued more than 240 hours of leave used their accumulated time before the end of the year because it did not carry over to the next year. A staff member reflected that this was the case with several staff members in the makerspace. He also indicated that some makerspace staff members began helping with other library departments/programs such as the virtual reference chat and the music programs. Interview data revealed that staffing issues were library-wide:

> Then also we have been very short on staff during the pandemic, not necessarily my department but the library as a whole. During the pandemic, a lot of people either retired or went back to school, or just left and went home. So even as we were opening up, our children's department was very short staffed. So on occasion, we would help them out in their info desk. We also sometimes help out in like the public access computer lab given that those are more like the essential services. We help supplement there.

RQ2: Cross-Case Analysis

Both makerspace sites relied on city government funding and experienced the effects of funding cuts during the pandemic. These funding cuts affected each site differently. At Site One, the funding cuts affected the number of staff. At Site Two, funding affected equipment and materials. Site One reduced and reconfigured makerspace offerings and repurposed community funding. Site Two responded by

reusing old equipment, reallocating grant funds, and seeking an additional outside funding source.

While staffing challenges at Site One were reportedly a result of funding, the staffing challenges at Site Two were a combination of labor relations and limited number of staff library-wide. Site Two interview data revealed that job descriptions were subject to union negotiations. Makerspace staff waited for negotiation results and volunteered to created virtual events when "telework" was approved. They also volunteered to assist other library departments during the library-wide staff shortage.

A comparison of both sites' efforts to engage with patrons/makers revealed several responses. Makerspace staff at Site One held regular, synchronous online events for the staff and guests to present their projects while viewers interacted in the chat (text). They offered individual "virtual guided access," a two-part interactive teleconference and printing/cutting service for the purpose of product creation. Once the Zoom teleconferencing platform was approved for use, Site Two offered synchronous teleconference maker presentations which provided an opportunity for viewers to interact via chat (text). They also offered regular interactive mending workshops. Table 4.8 provides a summary of the challenges faced by the two sites and their responses.

Table 4.8. Summary Table of Challenges Faced by Makerspace Staff and Their Responses

Challenges	Site One Response	Site Two Response
Funding	Reduced makerspace offerings by 20% Reconfigured the calendar to maximize efficiency Support efforts to form a library district Repurposed unspent operating funds	Service and reused old equipment Reallocated of LSTA funds Pursued additional grant funds
Engaging with makers	Held synchronous show-and-tell events Introduced "virtual guided access"	Tested multiple teleconferencing platforms Used Zoom after approval Held synchronous virtual events
Staffing (not due to funding)	N/A	Checked on employees during administrative leave Volunteered to create virtual events once "telework" was defined Assisted/supported other library departments Waited for designated employee to install software

Summary of the Responses of Makerspace Leaders to Pandemic Challenges

In this section, I presented data to address RQ2 by examining the ways that makerspace leaders responded to challenges they faced throughout the COVID-19 pandemic. I first presented challenges and responses by makerspace leaders at individual case sites. Then I examined the data across the case sites. In the following section, I will present data pertaining to the evolution of makerspaces during the time period from pre-pandemic to reopening.

The Evolution of Makerspaces during the COVID-19 Pandemic

In asking Research Question 3 (RQ3) "How did makerspaces evolve during the COVID-19 pandemic?", I focused on data that represents how makerspaces changed from before the start of the pandemic to the time that the makerspaces reopened for in-person, patron access. I provide context for the analysis by including information about the reopening timeline for each site. The data indicated that the makerspaces experienced changes in staffing, funding, operations, equipment, and offerings.

RQ3: Within-Case Analysis of Site One

The makerspace reopened in June 2021 with a staff of 2.5 full-time members, a difference of one full-time staff member since before the pandemic. Health guidelines included a mask requirement for all in-person activities. A staff member reported during the interview that they planned for a period of about three months for the reopening by trying to "reconceive normal operation." He described the process:

> We're really doing the kinds of numbers now that we were doing in 2019 with one less full-time staff person, and it has everything to do with sort of a lot of collective work.

> It's like writing an album every time we change the program. All the band members get in, and we really struggle and hash out how could this work, what does look like, is it as efficient as it can be, are you going to get burnt out, can we sustain this, and is it going to provide the maximum amount of programming to the public that we can. We've learned the hard way how to approach that, and we've had a really good success getting restarted.

The reopening occurred incrementally beginning with in-person access twice weekly and "guided access" by appointment. The staff posted instructional videos and equipment orientation videos online for virtual, asynchronous, unrestricted access. Two months after reopening, the staff posted a series of asynchronous videos that featured an outside instructor. The first in-person outside instructor event and screenprinting event by appointment were held three months after reopening. A staff member reported that after reopening, the makerspace in-person attendance was similar to what it had been in 2019 with 25-35 patrons per day attending the in-person studio and guided access options. The staff member also reported that wood shop in-person attendance increased by 200% since 2019. The staff planned and advertised an in-person gallery event for early 2022. Table 4.9 includes a summary of the access and operations for Site One at the time of reopening.

Table 4.9. Summary Table of Access and Operations of Site One after Reopening

Type of Access	Terms of Access	Equipment, Services, & Programs
In-Person	Open session (2, 6-hour weekly sessions), drop-in	Use of equipment (exceptions--laser cutters, CNC router, wood shop equipment) and supplies
	"Passive Instruction," drop-in	Self-guided tools placed throughout the space: color code guide, fabric guide, stitching guide, guide to 3D printer quality variances
	"Guided Access"/Orientation, by appointment	Use of laser cutters, CNC router or wood shop equipment with staff guidance
	Classes led by outside instructors, various topics; by registration	Group programs; materials/equipment vary
	Gallery, drop-in during event hours	Public showcase of makers' work, specified dates/times
Virtual	Instructional videos (various topics, staff and outside instructors)	24/7 open access online
	Equipment orientations (required prior to specific equipment use)	24/7 open access online

Changes included the addition of MIG (Metal Inert Gas) welding equipment, purchase of more 3D printers, and a revamping of the woodshop schedule to a 3-tiered system ranging from independent to completely supervised access. Appointment reservations for guided access options and classes were streamlined using the online calendar system. The two equipment orientation videos posted on the makerspace's new YouTube channel were required viewing for patrons to use the laser cutter and/or MIG welding equipment. Interview data indicated that estimated program offerings decreased by 20% with the reduced staff and budget. Professional development and camps were not reintroduced after reopening.

*RQ*3: Within-Case Analysis of Site Two

The Site 2 makerspace opened for limited, in-person patron access in June 2021. The access was by appointment only and limited to one patron in each lab of the makerspace at a time. Available three-hour appointments included the 3D printer in the fabrication lab, podcasting (audio-recording) equipment in the studio lab, and digitization equipment in the memory lab. According to a staff member, the appointments were scheduled at least 30 minutes apart so that patrons arrived at the makerspace check-in desk at different times. Safety/equipment orientation shifted from the pre-pandemic small group to one-on-one appointments. A staff member described this shift:

> If it's your first time visiting the space, in the beginning of the appointment you do the safety guidelines. You sign the release. The appointments are three hours long. The first hour really is the safety guideline and depending on the machine, like the 3D printers might take longer to do to teach the person how to use a 3D printer. That would be like the half, hour and a half for the 3d printers, and then in the last half, the customer uses the equipment on their own, so I would say it's more individualized.

By September, all of the makerspace staff had returned to working in-person. The makerspace opened for groups in November. The first session was a training workshop for a group of librarians who had registered to participate in the interactive gaming grant. A makerspace staff member who created a prototype using the raspberry pi and the library's historical mural volunteered to lead the session. The second group event was for a group of registered volunteers interested in participating as "fix-it coaches" as part of a future repair clinic. A makerspace manger led the program in preparation of offering a

"fix-it clinic" after the first of the year. One-on-one in-person appointments continued through December. The makerspace returned to virtual access only in January 2022 in an effort to help control a virus surge.

Maker presentations continued to be held synchronously via teleconferencing and by appointment only. Recordings of these presentations were posted for asynchronous open access after the addition of subtitles. Makerspace staff also posted other recorded maker presentations that had been held synchronously before reopening. Table 4.10. contains a summary of the access and operations at Site Two after reopening.

Table 4.10. Summary Table of Access and Operations of Site Two after Reopening

Type of Access	Terms of Access	Equipment, Services, & Programs
In-Person	By individual appointment, through December 2021	Safety/machine orientation
		Fabrication Lab--3-D printers
		Memory Lab--AV digitization equipment, computers, and scanner8mm/Super8 film scanner
Virtual	Registration required	Synchronous maker presentations, classes/workshops (various topics)
	24/7, no library card required	Asynchronous events
		Libguides

RQ3: Cross-Case Analysis

Both makerspaces exhibited evidence of change from before the pandemic until the time they were open to in-person patrons. Each makerspace shifted from full in-person access to a temporarily closed space for patrons and staff to a space open for staff only and finally reopening for patrons at differing levels of access.

At reopening, Site One, in-person hours were reduced by nine hours weekly. Guided access was available by appointment only and included a session for the new MIG welding unit. The staff reconfigured the wood shop schedule with appointments available for patrons depending on the type of wood shop equipment and the amount of supervision that patrons needed based on their skill levels. The online calendar reflected those offerings and served as a place for patrons to register for the events.

A makerspace staff member explained some of the changes during teleconference for patrons:

> We've changed the structure of how we schedule things in the shop to try to balance out the range of the projects people might be working on. When you look at the calendar, you'll see there's beginning, intermediate, and advanced; and in the description, it'll list what tools fall under what categories, and it's just a way to have multiple people in the shop working on different projects and not wanting the same machines at the same time and to kind of divide the staff's attention over the space just to kind of maximize people getting through.

The Site Two makerspace also opened incrementally with in-person access being limited to individual appointments, one per lab, a change for the studio lab's former drop-in access. Further limitations applied to the equipment in both the fabrication lab and the

studio lab as patrons could access only the 3D printers and audio-recording equipment in the in-person appointments. A staff member described the process:

> We started out with the memory lab given that that was the most isolated space where a customer could just go in and shut their door. Everyone also was required to maintain their mask while they were using the space and then once that was successful, we then incorporated the 3D printers and did appointments. So after the 3D printers, we then added the audio recording session which was in our podcasting studio where customers can come in and use the equipment to record a podcast, a voiceover, and we even had someone come in and bring an instrument and record it. So that's been the main three areas that we've been open for.

The online calendar listed the appointments and classes as long as the registration was open. The calendar changed daily as new events were added and registration quotas were met. Once a class/appointment was filled, the event was removed from the registration calendar.

The format of the required equipment orientations changed for both case sites. Before the pandemic, the Site One makerspace staff held equipment orientations by appointment for specific machines. During the pandemic, the staff produced and posted instructional videos for patrons to access as the first step in orientation for specific machines. After the pandemic, the orientations returned to in-person access. Staff required patrons to view posted video orientations for specific machines before registering for the in-person orientations. The updated makerspace calendar listed the available appointments for in-person orientations along with information about the required video orientations. At Site Two, the orientation sessions shifted from the small

group format to an individual format. At reopening, sessions were limited to the machines available for access (3D printers, audio recording equipment, digitization equipment). The calendar listed the available appointments and provided registration links for patrons.

The case sites reduced in-person class offerings. The Site One makerspace began offering classes led by outside instructors approximately three months after reopening the space to patrons. A staff member described the gradual reintroduction of group classes: "We're really trying to start with some known, solid instructors, people that we don't have any question about their ability to come in, what the expectations are here, and who have delivered big time for us in the past." The staff suspended other group instruction (professional development and camps). The Site Two makerspace also reintroduced group classes with the first classes approximately five months after reopening to a specific group. In describing the first class, a makerspace staff member said:

> We also have never taught a safety guideline in that scale, so it's also an opportunity to see if it works or not. So we'll teach the safety guideline. We'll have everyone sign the release, and then our partners will present on the fix-it program, so it's really an opportunity for the coaches to meet each other and learn about the program.

Both sites had expanded virtual access during the pandemic, and all previously posted video content remained accessible online. The Site One makerspace staff posted additional instructional and orientation videos on the channel after reopening. Some of the orientation videos were required viewing prior to in-person orientation. At Site Two, the staff continued posting maker presentations and posted some that had been recorded

during the pandemic. The maker presentations continued with registration available on the library calendar.

Table 4.11 provides a summary of the evolution of the two sites with a comparison of elements from before the beginning of the pandemic and after reopening.

Table 4.11. Comparison of Evolution in Sites 1 and 2 from Before the Pandemic to Reopening to In-Person Patrons

Makerspace Element	Site 1	Site 2
In-person access	Reduced in-person open session hours from 21 hours to 12 hours weekly.	Reduced equipment access to individual appointments for only 3D printing in the fabrication labs.
	Maintained guided access by appointment including new MIG welding equipment.	Maintained individual appointments for digitization.
	Reconfigured wood shop guided access considering patron skill level.	Shifted studio access from drop-in to appointment only for audio equipment only.
Equipment orientation	Returned to in-person orientations by appointment; added MIG welding program orientation.	Shifted orientations from small group to individual settings
	Select orientations added an asynchronous online component.	
Classes	Reduced number of classes led by outside instructors.	Shifted classes to virtual teleconferencing by registration
	Suspended professional development. Suspended camps	Limited group classes to training events
Virtual access	Expansion of virtual offerings including asynchronous instruction and orientation videos	Maintained libguides. Expanded asynchronous instruction and

maker presentation programs.

Summary of Evolution of Makerspaces

In this section, I presented data to support RQ3 by examining evolution of both case study sites. Findings indicate changes in terms of staffing, funding, operations, equipment, and offerings from the time before the start of the pandemic in March 2020 to the time that the makerspaces reopened for patron in-person access in June 2021. An analysis of the data across cases was also presented.

Chapter Four Summary

In this chapter, I presented data that detailed the context and data findings for both case sites individually as well as across cases. I then provided the findings organized by research question, subdivided by the within-case analysis for each site, and then by cross-case analysis. Themes were assigned to data and presented along with corresponding data. In the following chapter, I will present the summary and discussion of the findings as well as implications for makerspace leaders and suggestions for future research.

CHAPTER FIVE: DISCUSSION

Introduction

The purpose of this descriptive case study was to describe the ways that makerspace leaders at two sites adapted and continue to adapt their makerspaces in the context of the COVID-19 pandemic. This study included two sites located in different geographical locations in the United States, both affected by state, city, and local health guidelines. The sites were public library makerspaces established prior to the COVID-19 pandemic. They differed in equipment, access, leadership, and offerings. The following research questions guided the study:

(RQ1) How has the pandemic affected makerspace access, and operations, and the teaching and learning that occurs there?

(RQ2) How have makerspace leaders responded to the challenges of the pandemic?

(RQ3) How have makerspaces evolved during the COVID-19 pandemic?

I collected data including interviews, virtual field observations, documents, webpages, and public videos virtually which was a unique feature to this study. I stored and analyzed the data with NVivo QDAS. I presented the data findings by detail organized by research question for the within-case and cross-case analysis. In this chapter, I present a discussion of the findings beginning with the context and continuing by research question.

Discussion of the Findings

In the following section, I will discuss the findings identified during data analysis and connect them to the literature. These will be discussed beginning with the context and followed by the topics that I examined in each research question.

Context

In this study, contextual data indicated that prior to the onset of the pandemic, both makerspace sites operated primarily in physical spaces and offered in-person access for library patrons to use the makerspace equipment by appointment or by dropping-in to make something, attend classes, interact with other makers in the space, and/or participate in events. This is consistent with how makerspaces in public libraries have been regarded as physical places where people gather to make things (e.g., Brady et al., 2014; Britton, 2012; Maker Media, 2013; Moorefield-Lang, 2015; Peppler & Bender, 2013; Resnick, 2014). Along with the physical spaces, the sites did have an online presence established on the main library website. The sites had a variety of technologies and materials available for patrons to use, a characteristic commonly associated with makerspaces described in the literature (Hsu et al., 2017). Many of the technologies found in the makerspaces in this study are listed in the literature as common to makerspaces. These included 3D printers, laser cutters, circuits, sewing machines, vinyl cutters, and computer numerical control (CNC) machines (Brady et al., 2014; Burke, 2015; Resnick, 2014).

RQ1: Effects of the Pandemic on the Operations and Access in Makerspaces

The pandemic influenced access and operations at both sites in terms of physical access. Both sites experienced abrupt, temporary closure of the physical space which

initially halted in-person access to everyone, including staff. The pandemic also affected ways that teaching and learning occurred in those spaces, specifically in terms of technology.

Focus on Communities of Practice

Makerspaces have typically been defined by physical location and the activities therein (Brady et al., 2014; Britton, 2012; Maker Media, 2013; Moorefield-Lang, 2015; Peppler & Bender, 2013; Resnick, 2014). In this study, the physical makerspaces became inaccessible for staff members for a few months at the beginning of the pandemic. Patrons were not granted in-person access at either site until more than a year after the closure. While the in-person access was suspended, the makerspace activity did not cease. Instead, the makerspaces emerged as a community of practice, a concept that was identified in the literature (Halverson & Sheridan, 2014). Although closed to in-person access due to the pandemic, the makerspaces in this study maintained the elements of communities of practice: a common domain of interest, shared community, and shared practice (Wenger, 2011). They shared a common domain of interest—making. Evidence of the second element, shared community, emerged quickly after the physical spaces were closed as both makerspace leaders and members of their communities worked toward the common goal of creating PPE by sharing files, instructions, and final products. They fulfilled the third element of community of practice by sharing their experiences with each other. This was especially evident during Site One's show-and-tell programs where guest makers who had accessed and followed a staff member's mask-making video, shared their experiences, and displayed the masks that they had made as a result. Although the physical location of the makerspace was accessible by only the

makerspace staff, the makerspace as a community of practice continued throughout the pandemic.

Community of practice emerged as a key concept in the ways that makerspaces were influenced by the pandemic. Therefore, I revisited the *Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* and revised it to include community of practice as a central, controlling element of the makerspaces during the pandemic disruption. The *Revised Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces* in Figure 5.1 illustrates the importance of community of practice as a central component in the makerspaces in the context of the pandemic.

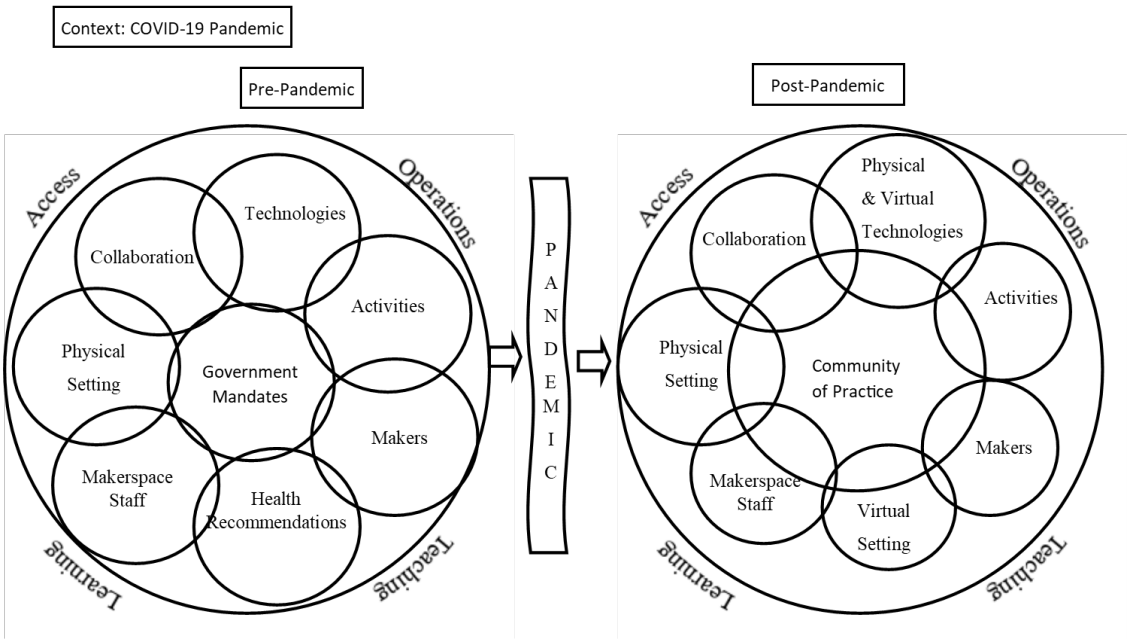

Figure 5.1. Revised Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces

Expansion to Virtual Platforms

At both sites, teaching and learning shifted from in-person activities to virtual activities as a result of the restricted access for only staff members in the physical makerspaces. In this study, makerspace staff were able to reconceive some of the in-person offerings in the virtual settings using Zoom, a teleconferencing technology in which makerspace staff members could communicate with patrons in an innovative way through audio and video across the internet in real time. At Site One, the "virtual guided access" became the virtual counterpart to the in-person "guided access," both of which included an individual instructional/learning session between a staff member and patron. At Site Two, makerspace staff members held the formerly in-person group mending workshop using Zoom. By reimagining the in-person activities onto a virtual platform, the makerspace leaders' actions are consistent with Moorefield-Lang's (2015) description of makerspace professionals as innovative technology leaders. The addition of the virtual platform is also indicated in the *Revised Conceptual Framework for Studying the Impact of Pandemic on Public Library Makerspaces.* The size of the virtual setting's circle in Figure 5.1 in relation to the physical setting is smaller indicating that the virtual setting is supplemental, not equivalent to the physical setting.

Both sites offered Zoom synchronous events which featured multiple hosts/guest presenters while patrons/viewers participated in the live chat (text). The format and content varied between the sites. Site One featured an informal conversational format with several staff members providing updates, taking on the role of maker by sharing their projects, and interacting with guests and chat participants. Site Two synchronous teleconferencing events featured one guest presenter followed a semi-formal format of

introduction, presentation, question-and-answer session. Both sites recorded and posted these events on a dedicated YouTube channel for asynchronous access. Makerspace staff members relied on teleconferencing via Zoom to offer these services and to interact with patrons.

The makerspace staff members at both sites created instructional videos to teach a variety of skills and projects. They uploaded these to a YouTube channel where anyone could access them asynchronously. Findings indicate common themes among the instructional videos. Those themes include (a) *giving an overview of the topic,* (b) *identifying materials,* (c) *explaining content,* (d) *demonstrating the instruction,* (e) *simplifying jargon,* (f) *offering choices,* (g) *building community,* (h) *maintaining safety,* and (i) *identifying next steps.*

Overall, findings indicate that the makerspaces shifted from full in-person access and operations to virtual access and operations. The virtual access and operations varied between the sites with synchronous and asynchronous options as well as variations of interaction among the staff, patrons, and makers. The shift from in-person to virtual programs and services was gradual, a learn-on-the-fly work-in-progress, as the makerspace staffs reimagined and reconfigured their delivery and programming, learned to use and introduced teleconferencing to engage the makerspace community, adapted to new/unfamiliar media and video technologies, and incorporated accessibility features. These adaptations are similar to those that Jones (2020) described particularly in the areas of offering virtual events for adults and of continuing to adapt throughout the pandemic. The videos at Site One transitioned from amateur cell phone productions to near-professional quality video. In an interview, a Site One makerspace staff member said that

2 ½ years before the pandemic, he had suggested the idea of creating a "virtual version of themselves" to cover equipment basics in order to free up time for the staff to be able to do other tasks, but the idea was tabled. Although not for the purpose of an unplanned disruption in service, the idea, had it been acted upon, may have made the shift from in-person to virtual smoother. The staff member reflected, "If you can envision something before it becomes an absolute necessity, make time and space to do it." In this study, Zoom and YouTube were vital technologies for makerspace staff/patron interaction and content creation during the time that the physical spaces were closed to patrons. These shifts are indicated in Figure 5.1 with the label "physical and virtual technologies." These are consistent with some of the responses of public libraries, although not specific to makerspaces, in Texas during the pandemic (Santos, 2020).

RQ2: Makerspace Staffs' Responses to Pandemic Challenges

The pandemic brought unexpected challenges for the makerspace staff at both sites including funding cuts and engaging the maker/patron community. Site Two also experienced an additional challenge in staffing the makerspace. The staff at both sites responded in such ways as to offer as many makerspace services and programs as possible.

Findings indicate that funding challenges identified in this study involved cuts due to reduced or eliminated funding sources up as a result of the pandemic or reduced funding as a result of reallocation to accommodate the pandemic situation. At Site One, the funding differentials caused both a temporary (furlough) and permanent (loss of job) reduction in staff. The reduced staff is represented in Figure 5.1 by the use of a smaller circle on the right (post-pandemic) than the one on the left (pre-pandemic). Makerspace

staff responded to this loss by reimagining the daily operations of the physical makerspace so that when the space reopened, they could operate as efficiently as possible. This included making intentional scheduling changes to accommodate several makers at various skill levels and requiring some orientation materials to be viewed online prior to an in-person orientation. At Site Two, funding to purchase equipment was not available as originally anticipated. The makerspace staff responded by performing maintenance on existing equipment so that it could continue to be used and requesting that available grant funding be reallocated to accommodate makerspace supply needs. While funding was a challenge mentioned in the literature as common to makerspaces for stocking equipment and supplies as well as maintenance (Maker Media, 2013; Resnick, 2014), the funding challenges faced by these sites in the context of the pandemic were unique.

With the temporary closing of the physical makerspaces, both sites faced a challenge in engaging patrons/makers without their accessing the physical setting similar to what Kinnula et al. (2021) described. Findings indicate that teleconferencing (Zoom) played a key role at both sites in shifting the communication from the one-way communication of recorded video to two-way and multi-directional communication as the technology provided a way to interact with patrons/makers in a synchronous, virtual environment. The makerspace staff at Site One engaged patrons in regular show-and-tell events in which staff, guests, and patrons interacted using Zoom. Findings identified three main show-and-tell themes: (1) *building community,* (2) *leading as a maker,* and (3) *sharing maker experiences.* Incorporating teleconferencing was a challenge initially for staff at Site Two due to a city government ban on the teleconferencing platform of choice

(i.e., Zoom). Once resolved, the staff members relied on teleconferencing technology for their interactive maker presentations. Site One used teleconferencing for one-to-one interactions with patrons as part of their "virtual guided access" service, for keeping their community updated on the status of the space, and for informal show-and-tell events featuring multiple guests.

During the virtual synchronous programs, findings indicated various levels of engagement among the staff and the participants. At times, communication was one-way, from staff to makers or viewers such as the staff giving instruction to create a project or operate a machine. Sharing a creative experience, communication similar to a lecture, was another example of one-directional communication. Other times the communication was two-way such as the makers asking questions of the staff members, the viewers asking questions of the presenter, or the staff members asking questions of the makers. Still other communication seemed multi-directional similar to a conversation with encouragements, comments, questions, and feedback being exchanged among several participants. Roles shifted as staff members identified as makers, and makers led staff members in creative processes. During the presentations, participants encouraged one another, asked questions, provided positive feedback, and showed enthusiasm. Staff modeled the concept of community learning and encouraged viewers to either try the projects/techniques at home or plan on trying at the makerspace when it reopens. Learning occurred informally in a conversational, friendly and almost familial manner in which presenters and observers take various levels of active roles, whether it be questioning, adding content, or offering encouragement. Overall, teleconferencing was a

vital technology approach for providing instruction and engaging the maker/patron community both synchronously and asynchronously.

Findings indicate that a staffing shortage was a challenge for Site Two which employed more staff than Site One. With all except the manager being union employees, working conditions, such as telework, had to be negotiated before changes to pre-pandemic operations could be made. At year's end, many staff members took personal leave to use time accrued. Staff members assisted in other areas of the library which limited staff availability for the makerspace. Others resigned their positions during the pandemic due to non-pandemic related issues, making the pool of makerspace staff smaller. The managerial staff of the space responded with patience and flexibility, postponing some programs until more staff would be available.

The challenges described in this study are unique to its context. One key characteristic—the ability to adapt to changing situations--that Koh and Abbas (2015) identified for library professionals in hands-one environments is evident in the ways that makerspace leaders responded to the challenges they faced.

RQ3: Evolution of Makerspaces Pre-Pandemic to Reopening

The makerspaces evolved in terms of access and operations, and teaching and learning opportunities during the context of the study. Both sites reopened in the same month after a 15-month closure, at different capacities. Site One reopened with one less staff member than before the pandemic. The staff reinstated open, in-person access to the site, but city-wide mandates initially required masking and social distancing. Open access was reduced from three days to two days per week with one hour less each day. The space featured new equipment, 3D printers and a MIG welding station. The staff operated

the woodshop, the laser cutter, the 3D printer, and the MIG welder by appointment only, along with a restructured woodshop schedule that incorporated patrons' skill levels. The staff reintroduced in-person teaching and learning opportunities through the by-appointment "guided access." Equipment orientations shifted to two sessions—an online component and an in-person component--for some machines. The posted asynchronous instructional videos remained posted online for global, open access. Outside instructors held small group classes in the makerspace for registered patrons only. The staff planned a group event, a maker showcase, for spring 2022.

The Site Two makerspace staff reopened by appointment only, allowing one patron per appointment in each of the three lab areas. The staff scheduled offset appointments to avoid in-person interactions between patrons and limit the number of people at the desk. The fabrication lab appointment was for 3D printing only. The studio lab appointment was for audio (podcast) recording only. The memory lab appointment was for use of the digitization equipment. The staff held safety and equipment orientations in small groups before the pandemic. After reopening, the staff held these orientations individually within the appointment times. The synchronous maker presentations continued with registration required via the library calendar. After the videos' subtitles were added, these were posted online, as had been done during the closure. The step-by-step instructional libguides which covered a number of topics remained accessible on the library website to support patrons in their use of the makerspace equipment. The makerspace staff offered two small group events, one for librarians and one for volunteer fix-it coaches. At both sites some of the elements that were changed and/or added to the makerspace offerings including orientation delivery,

online access of instructional videos and recorded events, and registration/scheduling continued to be part of the makerspace offerings after reopening to in-person patron service.

Implications for Makerspace Leaders

Unforeseeable circumstances are just that—unforeseeable. Public library makerspace staff may someday face another unforeseeable event, not necessary one as widespread as the pandemic, but perhaps one more localized such as a tornado, flood, hurricane, fire, etc., that causes a temporary disruption in normal makerspace access and operations.

The findings of this research challenge the definition of a makerspace as tied to place (Brady et al., 2014; Britton, 2012; Maker Media, 2013; Moorefield-Lang, 2015; Peppler & Bender, 2013; Resnick, 2014). The makerspace leaders in this study changed the way that the makerspace was implemented in order to offer makerspace services and engage with their communities without meeting together in a physical place. Thus, this study supports the idea of a makerspace as a community of practice with a common domain of interest, shared community, and shared practice (Wenger, 2011). Leaders may consider how their makerspace can function as a community of practice in the event that the physical place of the makerspace is not accessible.

The findings of this study support the importance for makerspace leaders to possess the ability to adapt to changing situations, one of five key competencies identified by Koh and Abbas (2015) for library professionals who provide services in library settings such as a makerspace. In this study, makerspace leaders adapted to changes in physical accessibility to the makerspace, unexpected funding cuts, imposed

and/or unforeseeable staffing shortages/reductions, and challenges in engaging with their communities. Each instance brought unannounced challenges forcing leaders to respond. Based on this research, a makerspace leader might consider ahead of time how equipment could be loaned/repurposed, how the makerspace staff could continue to engage with its community and what technologies might best support such engagement, what alternate funding opportunities are available, and how teaching and learning could continue without physical access to the makerspace.

Delimitations/Limitations

This multi-case research study included two makerspace sites in separate geographical areas of the United States. The findings in this study are contextualized in the two cases in the sample. Despite the inclusion of two sites, generalizability is limited for this descriptive case study (Miles et al., 2020). The cases are not representative of makerspaces across the country.

Delimitations

As the researcher, I determined the research boundaries. These delimitations included my choice of sites in the sample, the time limitations that I set for the study, and the choice to conduct the study in an all-virtual format. I selected sites that were accessible to me and that had leaders who agreed to share their experiences with me.

The context of this research was the beginning of the pandemic (March 2020) through reopening (June 2021) with data being collected through December 2021. The need to complete the study as a degree-seeking student affected the decisions pertaining to dates of data collection. I also chose to collect data before and after reopening for the purpose of comparison.

Because of the pandemic and limited access to physical spaces, I chose to conduct the interviews virtually. This allowed me to expand the geographical area of the potential sampling sites because virtual interviews were not limited by physical access. I may not have had complete access to some data that would have been available in person had I had physical access to the sites.

Limitations

Limitations are factors that occur that are not within the researcher's control. While I did choose to include conduct a multi-site research study that included two makerspace sites in separate geographical areas of the United States and those sites were within my control, I could not control the local, state, and federal government pandemic guidelines which may have affected the makerspaces. These guidelines varied from city to city, state to state and were not uniform throughout the country. The timeframe of the pandemic was also not within my control. There was little/no warning at its beginning in March 2020, and it continues. These variances were not in my control. Therefore, the findings are not representative of makerspaces across the country and are limited only to the cases in this study.

Another limitation was the availability of interviewees. Although I made reasonable attempts to secure interviews with all makerspace staff members at each chosen site, only one staff member from each site agreed to an interview. Perspectives of staff members who did not agree to be interviewed and patrons were available via the recorded videos. Had more staff members agreed to be interviewed, multiple perspectives may have changed the findings.

The context of this research was the beginning of the pandemic (March 2020) through reopening (June 2021) with data being collected through December 2021. At the time of writing, the pandemic continues. Therefore, the research was not conducted in a pre-pandemic/post-pandemic manner.

Future Research Recommendations

The findings of this study are limited to the individual cases and might not be applicable to any other makerspaces in any part of the country. To add to the research, case studies in public library makerspaces all around the country would need to occur. Such an endeavor might determine if findings in this study are consistent with public library makerspaces in other parts of the country.

By hosting events online, and publishing instructional and event recordings online, participation was no longer limited to patrons in a specific geographical area. Future researchers might examine how virtual environments make makerspaces more accessible. Studies might address the size of the virtual audience and its characteristics including how the audience extends beyond the local library community.

This study supports makerspaces as a community of practice. In this study, findings indicated that teleconferencing (e.g., Zoom) and video-hosting sites (e.g., YouTube) may be important technologies for makerspace leaders to maintain a community of practice. Further research is needed to support this finding. Other technologies may also contribute to a community of practice. Researchers should work to identify other technologies that enhance makerspaces as communities of practice.

Koh et al. (2018) noted that makerspace users may have different ideas of what community means in the makerspace. This may also reflect on the levels of engagement

among the staff and users in a makerspace. More research is needed to identify these levels of engagement and how the levels may affect the teaching and learning that occurs in makerspace environments. Researchers conducting future studies might consider examining the levels of community engagement in makerspaces. As this research suggests, some interaction was one-directional, bi-directional, or multi-directional. Researchers might consider examining the attitudes of patrons in makerspaces where various types of engagement among makerspace leaders and patrons occur.

This study was conducted during the COVID-19 pandemic. The participating sites did continue some of the practices/activities that were implemented during the time that the makerspaces were closed. Researchers may want to examine makerspace activities to see how many, if any, practices/activities continue to be part of these makerspaces. Such a study may highlight long-term effects of the pandemic on the makerspaces.

Reflection

This qualitative project was my first major research project, and I have learned much from it. From the start, I learned that choosing sites and establishing rapport with participants are critical first steps. During data collection, I found some tasks such as generating readable transcripts to be time-consuming; however, I learned that such tasks gave me an opportunity for initial analysis as I spent large amounts of time with the data. Understanding how to set boundaries in terms of when to stop collecting data and how to identify the saturation point became important for me to manage the project. Although I conceived the conceptual framework as a map or guide for the study, I learned that keeping an open mind enabled me to listen to the data and use the conceptual framework as a working document throughout the study.

Conclusion

The findings in this virtual multi-case study indicate that as a result of the COVID-19 pandemic, two public library makerspaces were temporarily closed to in-person patron access for more than a year. Yet, the makerspaces endured as communities of practice. With the physical makerspace inaccessible to patrons, makerspace leaders found new ways to offer services, events, and learning opportunities, and to engage with makers through the use of teleconferencing (Zoom) and video hosting (YouTube) technologies. Makerspace leaders faced unexpected challenges throughout the pandemic and responded by reimaging their operations, offerings, and scheduling as well as supporting alternate funding sources. Both makerspaces evolved from the time of closure to reopening and maintained some of the practices that they developed over the course of the closure.

Makerspace leaders who are concerned about unexpected disruptions in service might consider how such a lapse could affect their makerspace in terms of access and operations. By studying public library makerspaces that have experienced such disturbances, makerspace leaders may be able to make a plan to respond in a such a way as to keep makers engaged in a makerspace community of practice.

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